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AGRICULTURAL RESEARCH INSTITUTE

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# PAPERS

OF THE

# MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

EDITORS
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UNIVERSITY OF MICHIGAN
PETER OKKELBERG
UNIVERSITY OF MICHIGAN

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Professor Frank C. Gates requests that the following corrections be made in his paper on *Meteorological Data, Douglas Lake Region, Michigan,* in Volume IV, Part I. In Table VI on page 488 the 'Season total' under 'White' for the year 1921 should read 1632.7, instead of 1793.6, the 'Rate per day' should be 29.2, instead of 32.0.

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# THE NATURAL SCIENCE OF THE NATIVE AUSTRALIAN

### E F GREENMAN

NO matter how primitive a people may be, it may be said with some show of reason that they have at least the rudiments of a natural science Of course there was no primitive thinker who sat down on a stump and cudgeled his brains for answers to the questionings of his intellect Primitive people obtain what little knowledge of the powers of nature they possess by the trial-and-error method, to which they are driven not by intellectual curiosity, but by necessity When we compare primitive knowledge of nature with our own, it seems to amount almost to nothing, but after all the difference is one mainly of quantity and not quality, and has come about to a great extent indirectly, and not as the result of a continuous and connected activity of powerful minds impelled by sheer intellectual curiosity Primitive man depended for his knowledge of nature upon the unaided powers of his senses He had to interpret things by what he saw with the naked eye and oftentimes his interpretation was no further astray than ours would be under the same conditions. But, as it is, a long series of unrelated discoveries over an immense period of time finally converged and gave us the microscope, with which our natural powers are so aided that we may see things the existence of which our forebears never suspected

Primitive man, then, could have very little knowledge of the qualities of matter beyond those to be apprehended by the sense of sight, touch or taste Yet he knew that other powers and qualities were there, and to this knowledge, and the oftentimes futile and mistaken practices arising out of it, the name of natural science is given for the purposes of discussion

There is no record of any primitive people who have not had a technology — industries of some sort The simplest, and for that reason, perhaps the most primitive, industries, are the flaking of flint and stone, the shaping of wooden objects, the building of fire and the weaving of hair, bark and skin into string It may be said that in savage and primitive communities these processes rest upon a perfectly scientific basis The result, for instance, of applying pressure upon a flint in a certain way can be controlled, and it is so only because the manipulator has some knowledge of the properties of flint, which knowledge, vague though it may be, was originally based upon observation and experiment Certainly the maker of a Mousterian 'point' knew that flint was a different kind of thing from granite And so it is with the Australian natives, who are at the same time in the Paleolithic and Neolithic stages with regard to the treatment of stone The Australian knows that if he wants a knife, quartzite is the most desirable material, or if an adze, flint, or if it is to be an axe, a large diorite pebble must be found, chipped first, and then ground down with sandstone All this discrimination implies at least a vague sense of properties inherent in the materials of the environment Their knowledge in regard to some, if comparatively very few, of those properties, is exact and rational There is no superstition about such knowledge, nothing is taken for granted Folk tales and mythology arise not around the technical industries so much as around the less definite and grander, sublimer things, such as the weather, the mystery of growing crops, and the cycle of the seasons To the Australian there is no mystery in grinding down a block of diorite It is too hard work for him to fall to romancing about the reason why one stone chips and another must be subjected to rubbing And somehow or other, in the beginning, he arrived at this process by purely empirical methods, not by invoking the aid of supposititious laws of matter or of ceremonies of any kind It is probably perfectly clear in his mind that there is a definite relationship of cause and effect between applied pressure and a detached flake, or between pressure, applied by rubbing, and a worn-down surface

The Australian becomes familiar in a number of ways with the idea of matter as having physical and chemical properties.

He knows that wood is more tractable than stone He knows that fire destroys wood, but that stones only crack when subjected to heat He knows that water will put out fire, and that wood floats in water while stones do not He knows that wind will carry one and not the other He undoubtedly recognizes the difference between the organic and inorganic objects in his environment He must know that a tree grows, but that a hill is stationary and inert He probably knows even that friction produces heat, from the experience of sliding too fast down a rope, or grapevine strand, he associates heat with fire All about him he sees the materials of his environment continually manifesting potentialities, different materials acting in different ways, some with desirable, some with undesirable, effects, from his point of view Is it any wonder that he sometimes attributes to matter properties which it does not have?

In reading the books of Spencer and Gillen on the native tribes of Australia one almost gets the impression that the life of the average Australian from maturity to death was just one ceremony after another And it is probably true, at least of the Central tribes,[1] that a very great amount of their time and thought was given to the carrying on of ceremonies and to the observance of taboos which were lengthy and laborious In fact the country is so desolate and barren during certain seasons of the year that there was very little else to do but carry on the imitative, dramatic representations which have come to be known as 'Intichiuma ceremonies' The purpose of these ceremonies was to increase the food-supply

The chief peculiarity of Australian totemism is that a given tribe is divided into groups of several people, to each of which is assigned a totem-animal or plant, so that there will be, for instance, a lizard totem-group, a snake totem-group, a grass-seed totem-group and an emu totem-group. It is the duty of men of the lizard-totem to perform ceremonies which will result in increasing the supply of lizards, but men of this totem may not eat lizards, it is the duty of men of the snake-totem to perform ceremonies for replenishing the supply of snakes, but men of this totem may not eat snakes, it is the duty of men of the grass-seed totem to see that the grass-seed supply is not lacking, but they may not eat grass-seed And so on down through the list Thus a man may eat of the flesh of any totem-animal but his own The practices which are carried on by the totem-groups in order to increase the supply of the totem-animal or plant are aptly called 'ceremonies,' since, if the Australian native may be said to have anything resembling a religion, it is closely bound up with these ritual customs. They are commonly referred to in the anthropological literature, and by Spencer and Gillen themselves, as magic, or magico-religious procedures They seem to be made up of three separate elements

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[1] *The Northern Tribes of Central Australia*, by Spencer and Gillen Macmillan and Co, London, 1904. All the references in this paper are to this book.

1. Ancestor worship,
2 Imitation,
3 The use of materials as having chemical or physical properties

All three of these elements may be present in the same ceremony, or only one of them, or any two And in certain tribes or localities one element is stressed at the expense of one or both of the others It is those ceremonies which stress the use of materials as having physical or chemical properties with which this paper is mainly concerned The application of the term 'magic' to them seems to be a rather loose use of that term The contrast between the truly magical, or magico-religious ceremonies, and those which the term 'magic' does not seem to describe adequately, is best illustrated by examples

First, let us take an example of a 'magico-religious' ceremony from the Wongkongaru tribe of central Australia. The ceremony for bringing about rain is based upon a lengthy myth regarding the method in which rain was produced in the Ancestor-time, which plays a large part in all Australian customs The ceremony consists in the headman of the rain-totem donning articles of apparel or decoration symbolical of incidents in this Ancestor myth. To begin with, appropriately decorated, he sits down on the ground in front of an audience, a man on each side of him beating on the ground with a stone as he sings a refrain, the meaning of which he does not know Then he goes through a sort of dance in which he imitates motions which the ancestors are said to have performed when making rain Finally he sits down abruptly and the ceremony is over [2] For an example of a ceremony based upon the use of materials as having physical and chemical properties, that of the fish-totem of the same tribe will serve The headman of this totem paints himself all over with red ochre and, taking little pointed bones about an inch and a half long, goes into a pool of water He pierces his abdomen and other parts of his body with the bones and sits down in the water The blood from the wounds goes into the water and gives rise to fish [3] The difference between the two kinds of ceremonies is obvious One consists in singing songs, beating stones on the ground and dramatically representing the doings of the Ancestors The only imitative element in it is the act of the headman in looking up at the sky once or twice That is the only thing suggestive of the idea of rain The rest is quite arbitrary, pure magic But the second ceremony involves the manipulation of certain materials — the mixing of blood and water The supreme efficacy here is in the mixing of the two fluids — in a mechanical operation There is a magical element no doubt in this ceremony, but the point is that it is not by any means uppermost The mixing of blood and water by the headman of the totem is the important thing Probably the whole procedure centers around a vague idea that blood, so important to their own life, has natural qualities which can be put to other purposes

The Kaitish have a special form of 'magic' which a man may make use of to kill an enemy secretly He finds an ant-hill out in the scrub, sings a verse or two over it, and then brings it back to his camp, all this in secret There he pounds it up into a fine powder, and then some day when the whole camp is going out on a hunt he will make an excuse to remain, and in their absence he takes his ant-hill powder to his enemy's camp and scatters it over the ground in all directions. When the man comes back from the hunt and takes up his abode in his camp again, the powder begins to act, and his skin becomes affected, he commences to scratch himself, sores break out all over his body and he becomes more and more foul until he dies[4] In this case it is as if the sand from the powdered ant-hill were red pepper, or some germ-ridden powder The savage conceives a chemical quality in the sand by analogy with actually observed chemical qualities in other things But there are elements of magic here It is necessary to recite words over the powder This is the 'spell' so common to our own conception of magic And there is an evil intent, which usually goes hand in hand with the recitation of words to cast a spell

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[2] P 285

[3] P 287

The Kaitish and Warramunga tribes have a very potent form of evil magic in the shape of little pebbles, from which powder is rubbed off by a spear-point and dropped on the body of a victim while he is asleep[5] But these pebbles gain their virulence from medicine-men of another tribe, who make them and trade them to the users, after singing over them to give them the destructive power Wherever the purpose is an evil one the magic element is present But in both these practices the use of materials as having definite properties is easily distinguished from the magical part

Considered apart from the magic involved, the method is the same as that which characterizes modern natural science As to results, the native Australian usually finds what he is looking for, or if he does not, he has a reason ready to account for the failure And, moreover, sometimes his methods do work For example, in the case of the fish-totem ceremony wherein blood and water are mixed,[6] the essential thing is that it is a meddling with the elements of the environment in which his prospective prey lives, and such a meddling could have only three possible effects to increase the number of fish, to decrease their number, and not to have any result at all And the odds are probably not so great that anything the native may do in the way of meddling with the elements concerned will fall in any one of these three classes In the grass-seed totem of a certain tribe it is the custom for the headman to perform ceremonies over some collected seed and then scatter them in all directions[7] Of course the seeds take root, but the men of the totem attribute it to their magic, not knowing that they are practicing agriculture The Australian undoubtedly has a vague idea that by tampering with the materials he finds about him, he can in some way turn them, or their qualities, to good account He persuades himself that everything he does is successful, whereas only a few of his experiments are, and those accidentally His method is apparently that of Nature herself who sends out from a single plant millions of spores or seeds in the expectation, as we may say, that a few of them will be certain to find lodgment in conditions favorable to growth

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[4] P 466 [5] P 467 [6] P 287

The Australian has apparently made the generalization that the materials of his environment have what we describe as physical and chemical properties The generalization is, as we know, perfectly sound To call this natural science is perhaps to give it an undeserved dignity But the designation serves in the absence of a better one Certainly the term 'magic' does not fit The Australian native probably knows when he is using magic and when he is employing the natural qualities in things It is the general rule that, when he wants to use these natural powers for an evil purpose, he sings or performs mysterious passes over the object to be used In this way he endows his materials with more than their natural powers

What do we mean by magic? For one thing, we mean the control by a human being of an occult, extra-physical, supernatural force or being for a good or evil purpose This conception of magic we have received to a great extent from the Middle Ages Medieval witches and sorcerers were generally supposed to be in league with the devil There is another kind of magic, more characteristic of primitive peoples, which may be described as the control or diverting of a well-known, universal law of nature to an evil purpose Where magic is used for an evil design in Australia it is at the same time a selfish, individual, anti-social purpose. The practical use that is made by these people of the laws of nature is beneficial to all Accordingly, when an individual wishes to divert a natural law, he ascribes to himself a power to instill into the materials he uses, by singing to them, powers which he knows they do not have otherwise, or naturally And an evil purpose does not absolutely necessitate calling the use of materials magic, because there are materials known to have evil effects of themselves, namely, poisons

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[7] P 293.

Granting these things, it becomes necessary to say that when a universal law of nature is, however mistakenly, put to a good use, it is not magic, because the purpose is not evil and the process is that of allowing the laws of nature to work The fallacy is that the savage does not realize that because a certain kind of material acts in a certain way right before his eyes, it does not follow that other materials are going to do other things - that blood and water mixed are going to produce more fish, or that sand rubbed on the bark of a tree which lice frequent is going to take up into itself the life-quality of lice and disseminate it upon being cast about[8] All the Australian sees is that matter of all kinds has physical and chemical properties This is as far as he has carried his generalization He is not guilty, when he tries to make use of these properties, of conniving with occult forces, he looks no further than the laws of nature Neither does he arrogate to himself any supernatural power over materials, except when he wants them to do things which he knows very well they have no inherent power to do He is simply conducting an experiment in a clumsy sort of way, and is usually too hopeful to admit that the desired result does not always take place

When an anthropologist observes an Australian blackfellow rubbing sand on the bark of a tree on which lizards are often seen and then scattering it about to insure a good crop of lizards, he immediately classifies it as magic But to the operator himself it is a perfectly rational procedure Control of results is an element here, but it is no more an appeal to a magical force than when our foresters spray a tree in order to kill insects Both operations are appeals to invisible properties of matter, the only difference being that the Australian believes in properties which do not in that particular case exist To him it is nothing if the results do not follow so quickly as when sand is thrown on fire to put it out. He can explain it by saying that something or other which was essential was omitted from the process But sometimes his experiments do work, through chance It must have been in this way that the Indians of South America discovered the use of Peruvian bark for medicinal purposes They had no way of knowing its properties except by experimenting with it. And this experimentation was in the first place a perfectly random procedure, suggested by analogy with the use of plant materials as food, done in much the same way that a cat eats catnip It seems to be natural for men and animals to eat things when they are ill which they do not ordinarily use for food It is instinct, but instinct does not tell them which plant is a specific

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[8] P. 288.

Fifty years ago there were practices in common vogue which research has since shown had no justifiable basis But we do not refer to them as magic They belonged to the category of natural science just as much as certain practices which at present are generally credited, but at some future time will be found to be wrong Among breeders of thoroughbred animals it is today a custom, if not a law, that if a female has been crossed with a mongrel she is not available for crossing with a thoroughbred male for the purpose of raising blooded progeny until after a stated time But geneticists know that no contamination of the progeny is possible This mistaken belief on the part of the breeders is no more magic than the Australian method of bringing about an increase of lizards They both represent merely arrested stages in scientific discovery

An enumeration of a few Australian ceremonies will show to what an extent, and in how diverse ways, materials and objects are used to cure illness and to bring about increase of food by virtue of their natural physical and chemical qualities To begin with, there is a story of how a bundle of magical implements, bones, pieces of wood, crystals, and the like, upon being dropped on the ground, resulted in a very great explosion[9]

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[9] P 469

Where the Australians acquired the idea of an explosion is difficult to explain. But it aptly illustrates their knowledge of a rather unusual phenomenon of nature. There is a belief among certain tribes that when a spear-point is rubbed in the flesh of a dead man, it can be used with direful effect. This is very likely one of those lucky chances in which the materials are used in the right way. For the purpose of securing a downfall of rain the Gnanji people use crystals, which they pulverize and throw about in all directions, requesting the rain to come as they do so, and to bring the fish with it. The procedure here is exactly of the same nature as that in which in the last ten years charges of powder have been touched off on mountain-tops in order to bring on a much-needed shower. And the results in both case are quite the same. Men of the Mara tribe *increase* the supply of honey-bees by scraping powder from a large rock in their country which looks like a honey-bag, and blowing it about, this scattered powder is supposed to give rise to bees.[10] In the Anula tribe, when more crocodiles are desired, the men go to a water-hole in their country where there is a big rock out of which crocodiles come, and break up sticks from the mangrove trees that border the pond and throw them at the rock.[11] The rain-making ceremony of the Anula people consists of making an arched bundle of grass into the shape of a rainbow and setting it over the dead body of a kind of snake which is particularly abundant in the rainy season.[12] If, as a result, it rains more than was calculated, the downpour may be stopped by simply taking a green stick, warming it in the fire, and then striking it against the wind.

The bull-roarer is extensively used in Australia, as indeed in other parts of the world, as a means of bringing about rain. Whirled in the air at the end of a string, the bull-roarer stirs up a considerable breeze and produces a sound very much like that of the rushing wind in a storm, and it may be that this resemblance has led primitive people to believe that rain can be brought about in this way. It is merely a manipulation of the elements concerned in rainfall. The logic is clear. When it

[10] P. 312.   [11] P. 313.   [12] P. 315.

rains the wind blows Therefore if one can make the wind blow it will rain

In the Tjingilli tribe there is a method by which a man may cure his headache by wearing the rings on his own head which his wife wears for decorative purposes [13] The theory is that the pain passes into the rings, and that it can then be thrown away with the rings, into the bush Stomach-ache is cured in the same way, the rings being laid on the man's stomach for a while and then tossed into the bush [14] After a time his wife searches for them, and if she finds them, continues to wear them in the usual way For the purpose of making a lean woman fat the Warramunga people procure an especially fat young opossum and give it to the woman to eat [15] Among the Central tribes, the hair of a dead man is preserved and made into an implement which is carried much as a rabbit's foot, and is supposed to impart to the owner certain powers which the dead man possessed [16] This is much the same kind of reasoning which underlay the doctrine of plant signatures which went out of vogue in our own civilized world not so long ago In both cases, the results were vague enough to leave considerable room for conviction that the process was effectual In both cases nature did the work, but it was attributed to the mechanism of the process

Among the Ilpirra there is a tradition relating to a man who in the Ancestor-time plucked out boils from his body and threw them down on the ground, where they changed into stones [17] If these stones are struck with spears, the spears are, as it were, inoculated with the essence of the boils, which essence can further, along with the spear, be projected in the direction of any individual upon whom it is desired to inflict boils In this case it is perfectly clear that the Australian attitude toward substances is, at least partially, scientific The rules for inoculating an enemy with the essence of boils are the same as for the injection of any other poison. The instrument must be first dipped in the poison, or touched with it, and then the victim pierced When the beliefs of the Ilpirra people about the origin of these stones are taken into consideration, the whole thing from beginning to end is perfectly logical The Ancestor stories, to their undiscriminating minds, are true They are history, no more and no less Therefore, when a man of the Ancestor-time threw down his cast-off boils, which turned to stone, it is not beyond the ordinary behavior of things in general that these stones should still contain the essence of boils, and that a little of them rubbed on a spear-tip could be impregnated into an enemy with results quickly disastrous to him There is no appeal here to any vague, nefarious agency, no witchcraft nor mumbling of mysterious words Anybody can do it The appeal is entirely to the laws of matter, and is an incipient scientific procedure It is just such things as this which it is now the style in anthropology to refer to as magic The evil purpose is present here of course, but the efficacy of the whole act is in the character of the stones as petrified boils

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[13] P 474. [14] P 474 [15] P. 476 [16] P 477 [17] P 469

Note in these ceremonies and so-called magical practices which have been cited that there are (1) no appeal to a god or a devil, (2) no dependence upon any hypothetical malign potentiality in nature, (3) and no dependence of the operations upon the particular personal powers of any one man

If there is one thing that is perfectly certain about these Australian 'ceremonies,' it is that their evil magic is largely, if not completely, dependent upon the casting of a spell by 'singing' the object to be used Spencer and Gillen devote a long chapter to this subject in *The Northern Tribes of Central Australia* under the heading of 'Magic'[18] And though it is not indicated in the heading, most of the practices here described are of an evil nature, that is, concerned with killing or injuring an enemy. Incidentally, it is unlawful for a man to use any of these magical means against a fellow-tribesman, and any infringement of the law is punishable by death To quote the first sentence in this chapter "The form of magic most widely spread over the whole of Australia is undoubtedly that which is associated with pointing-sticks and bones" These objects are carefully prepared by being wound with hair-string, painted sometimes with red ochre and so forth, and then 'sung over.' After

[18] Ch XIV, p 455.

this they are simply pointed in the general direction of the enemy, who may be miles away, a few mysterious or imperative words uttered, and the evil magic is projected through space to the enemy who is either killed at once, or at least enters upon a period of decline which ends in his death The method here is one involving a physical quality of matter, namely that of being projected through the air from the end of a pointed stick or bone, and of maintaining in flight the direction received from the disposition of the instrument from which it started The analogy in this case is probably taken from that of the flight of a spear from a spear-thrower But since the purpose is evil, the bone or stick must be sung over and the death-dealing quality which is projected is imparted by this magic song, and is not supposed by the savage to be an inherent quality of bones and sticks as natural objects This almost universal use of the song where evil magic is concerned renders it highly probable that in those rites wherein it is not used, as in the increase of food or the curing of disease, the efficacy of the process is deemed by the native to be in the physical and chemical properties of the materials used

An incipient science is not the main factor, however, in these Australian ceremonies They consist, perhaps, for the most part of magic, and magico-religious elements It is claimed in this paper only that it is possible to distinguish a purely scientific knowledge and method, and that it is necessary to discriminate much more closely than has been the custom in the past when assigning primitive practices to the categories of magic and religion. It is, perhaps, an innovation to regard any primitive customs as having any scientific basis whatever, but it is certainly possible to prove that many of them have neither a magical nor a magico-religious foundation. Where scientific knowledge and method do exist in Australian practices, they are for the most part interwoven with magic, and perhaps even with a rudimentary religion.

UNIVERSITY OF MICHIGAN

## SUPPLEMENTARY NOTE

My old pupil, Mr E F Greenman, has kindly let me see his paper on "The Natural Science of the Native Australian," in its first rough draft, and has asked me to say in a few words whether I agree with him So far as he looks for incipient science in such technical processes as the chipping of flint implements, I am in full accordance with his view I might, perhaps, refer to a book of my own, "Psychology and Folklore," where in dealing with the origins of medical science I distinguish various technical methods of dealing with wounds, with child-birth, and so on, as on the way to become science in the sense of "organized common sense" But I am not equally convinced of the success of Mr Greenman's attempt to distinguish a scientific element in those symbolic acts which are characteristic of what we sometimes call magic and sometimes religion At any rate I should say that, just in so far as there is symbolism, conscious or sub-conscious, the material qualities of the objects used in the rite are not considered as such, but are treated as largely irrelevant for the ritual purpose in view Of course such objects are bound to retain some of their ordinary attributes in the new context, or they would be unrecognizable and hence incapable of being employed as symbols A totem-animal, for instance, need not for ritual purposes behave exactly as does the real animal which is hunted All that is needed is that it should remain sufficiently like the actual beast to suggest those ideas of alliance, mystic guardianship or what not which the totemist is seeking to express figuratively I do not think that it makes any difference whether a social or an anti-social intention pervades the act in question My point is simply that, so far as it is understood symbolically, it cannot be understood literally and in terms of the ordinary or objective behavior of the things referred to in the rite On the other hand, I would freely admit the possibility that the free manipulation of things for purely symbolic ends does often *per accidens* lead to results which, being manifestly profitable, are afterwards exploited for everyday uses Mr Greenman gives an excellent example of what I mean when he suggests that seeds scattered with a purely symbolic end in view, namely, to express the desire for the spread of vegetation, may have by their casual ripening, made the folk think of planting a garden, though I would add that there is no evidence that anything of the sort actually took place, and, again, that a reason why it may not have taken place is that humanity has a remarkable capacity for keeping their magico-religious and their utilitarian notions in logic-tight compartments. Finally, it must not be forgotten that technical processes such as building a house or a canoe are among primitive folk always accompanied by magico-religious rites Even so, I suspect the savage is for the most part subconsciously aware of a difference between his technology and his magic or religion, and realizes, in however dim a fashion, that his doorpost sustains the roof mechanically, whereas the victim buried beneath the doorpost sustains it in another and non-mechanical way Meanwhile, Mr Greenman is to be congratulated on calling our attention to a very interesting, though difficult and disputable, problem

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# RELIGION AT THE ALGONQUIAN LEVEL

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IN the conception of the scientists, a paper, to possess merit worthy of being presented in their presence, must contain the result of original investigation No claim of that kind can be made for these notes on the primitive religion of the Great Lakes region In fact, there is left slight opportunity for research except in literature The Indians that are now living are a mixed breed With their hybridization, their primitive beliefs have also become polluted There are glimmers in their legends and folk-stories of the mental attitude of their ancestors, but it is as difficult to determine what parts are absolutely pure as it would be difficult, by physical and laboratory tests, to ascertain what percentage of white blood flows in their veins If it were possible to lift oneself out of his own culture and beliefs, and to drop down into the world of primitive people without prejudice, he could grasp their notions and reactions with considerable clearness.

*The Jesuit Relations* and accounts of early travelers constitute a vast fund of information about Michigan Indians, as the missionaries found them The purpose of the missionaries was to change religious ideas to their own; otherwise, there would have been no missionaries Being intent upon making converts, they did not grasp the actual content and meaning of the conceptions of the people among whom they labored They saw outward religious practices but did not comprehend, or, if they did comprehend, failed to note the underlying impulses and feelings that led to and made beliefs what they were Thus they gave their own viewpoint, not that of the Indians

Ethnologists, taking the data they have gathered from groups still holding a degree of original tribal integrity, and from remote islands and countries, have reconstructed, probably with much accuracy, the pattern that can safely be assumed to be that of the Algonquians and others living in this region before the introduction of Christianity The religious pattern of primitive people is much the same generally, and probably sprang, by necessity, from the nature of man acting upon and influenced by the general cultural complex

Primitive people seem to be intensely emotional in spite of the stolid demeanor and taciturnity they manifest when first approached The American Indian was a mystic and the greater his secretiveness, the deeper, oftentimes, was his feeling In fact, he deemed his emotions to be his own personal affairs. They rooted back in experiences he had, when, in his youth, he was struggling alone for his guardian spirit to manifest itself He was secretive even about his real name, because he conceived that to be part and parcel of his personal substance

In order to secure the coming of his guardian spirit, which was to him sacred, he had to subject himself to a rite of bodily discomfort such as fasting, purgation, and even to some form of self-inflicted mutilation The spirit, when it came, was usually in the form of some medium-sized animal, although it might be a legendary being or even a lowly insect Whatever its form, it became his guardian and personal protector, yet it was not in constant attendance, being needed only at particular times To secure this guardian was to acquire a manito The animal that appeared to the aspirant in his dream was not his real guardian, but the spirit of the animal was such. His supposed revelation gave him his tutelary protector and determined the part he would play in society, whether warrior, hunter, shaman or social hero

There was among many tribes a highly differentiated priesthood, especially among those of a well-developed political and ritualistic order, but there was not such high organization among the Michigan Indians With them the shamanistic and priestly offices were combined in the medicine-men. Shamanism had its full bloom among the Siberian tribes and the word *shaman* has been borrowed from that quarter For an extended discussion of shamanism and religion one may consult *Aboriginal Siberia*, by M A Czaplicka.

A kind of token between the guardian and the ward was jealously preserved This token was a charm supposed to be a carrier of supernatural power and, together with other precious belongings of the individual, constituted the sacred medicine- or war-bundle. Where there was a priesthood, one of the functions of the priest was to preserve and explain the community bundles These tribal bundles were public property, and different from the private guardian spirit bundle in that regard The bundles bring to mind the Urim and Thummim of the ancient Jewish priests

Many trained observers have dwelt with various Indian tribes for the purpose of studying their social customs, hoping to catch the actual purport of their ceremonies and the interpretation of their religious and social customs and beliefs, but David Zeisberger, a Moravian missionary to the Delawares of Ohio, writing in 1780, gives an account of the guardian spirit as lucid as that of any of the trained anthropologists, at least, his language is less labored and is non-technical

> They believed in numerous spirits or subordinate deities Almost all animals and the elements are looked upon as spirits, one exceeding the other in dignity and power There is scarcely an Indian who does not believe that one or more of these spirits has not been particularly given to him to assist him and make him prosper Thus, they claim, has been made known to them in a dream, even as their religious belief and witchcraft is alleged to have been made known to them in a dream One has, in a dream, received a serpent or a buffalo, another, the sun or the moon, another an owl or some other bird, another a fish, some, even ridiculously insignificant creatures such as ants. These are considered their spirits or Manitos. If an Indian has no Manito to be his friend he considers himself forsaken, has nothing upon which he may lean, has no hope of any assistance, and is small in his own eyes On the other hand, those who have been thus favored possess a high and proud spirit.[1]

The Indian's religion permeated his whole life and formed a big element in his culture. It is a mistake to infer that a primitive religion implies, according to our conception, anything of a moral element. The savage never hesitated to deceive the spirits whom he employed and in his mythology there were great tricksters Goodness is not the essential attribute of a primitive spirit, power or god A primitive American might observe trees to be uprooted or a stone to roll down the side of a steep hill His explanation of such phenomena would be like the following A spirit in the stone causes it voluntarily to change its place If an accident or disaster results from the movements of the stone, or from the blowing of the wind, a sense of awe arises in the beholder, a religious impulse is engendered There are various ways of going about stopping the mischief One is by direct propitiation, another is to attempt to appease the agitated spirits by setting in operation more powerful spirits as a counter-influence If the Indian sought to palliate the spirit powers by propitiation and peace offerings he was performing a religious act There is here, also, opportunity for the play of magic The whole trouble may be ascribed to a mischief-making magician who must be thwarted by one who has greater magical powers than he

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[1] David Zeisberger, *History of the Northern American Indians* (published by Ohio State Archaeological and Historical Society), p 132.

The difference between religion and magic is that in the former the powers are invoked directly, in the other there is a person or magician who, through his own instrumentality, starts, changes or stops natural force. In magic, spiritual agents are an important factor, but, in one way or another, are under the control of human agency The sorcerer is usually present, but magic can be projected and act from a distance and the magician be unknown. The word supernatural, or some synonym for it, will have to be called into use to explain these beliefs. It seems to embody the pith of any definition that may be given of animism, animatism and mana.

According to Paul Radin[2] two factors entered into the religious element first, a specific feeling, and second, beliefs, customs and acts associated with that feeling One of these beliefs, inseparably connected with the feelings, is that spirits are more powerful than man and control the other elements in life which he stresses In other words, the Indian sensed something that did not come to him through his sense perceptions and, after his fashion, strove to put himself into responsive relations therewith He was lacking in our conception of the natural, consequently had but feeble ability to distinguish between the natural and the supernatural, as we understand the terms[3] Attitude of bodily posture, movement of the hands, closing the eyes, a sanctimonious facial expression and bowing the head conduced to an emotional concentration, the full culmination of which is the religious thrill which, in its unbounded expression, was nothing more nor less than an aura Of course, the stereotyped posture may, and possibly often is, as with worshippers in a modern church, only a mechanical or artificial formula, and not accompanied by anything more than an indifferent or negative religious feeling.

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[2] *Journ Amer Folklore*, Oct -Nov., 1914

The missionary and other white influences have fabricated for the Indian some beautiful but misleading phrases "The Great Spirit" may be a good term for the one who coined it and for denoting his own conception of the superhuman but it is too difficult for the Indian to comprehend Erminnie A Smith,[4] speaking of the Iroquois, says

> But though talking with white men they frequently speak of the Great Spirit, yet in their worship they seem to have no very well defined recognition of the same, the term being used in a confused manner

This double form of giving heed to different religious formulae at the same time is not without parallel in other parts of the world The laymen in China, Japan and adjoining territory often seek divine assistance from Buddhist, Confucian, Shinto and other sources, adhering more or less to several religions[5] The Indian believed in powers outside of himself and in what he could discern in nature, but not in a personal divinity

Hobhouse[6] says

> It is natural for us to regard the human soul as the model on which the spirits of animals, plants, and inanimate objects are formed

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[3] Rivers, *Medicine, Magic and Religion*, p 30

[4] *Report Bureau Ethnology*, 2 112

[5] W K. Wright, *A Student's Philosophy of Religion*, p 103

[6] *Morals in Evolution*, p 374.

That is, the human soul is a kind of form over which the spirits are moulded Systematic anthropologists discern a stage earlier than animism, which Marett designates 'animatism,' in which immaterial things are regarded as if they were alive and plants and animals as if they were human, which makes a separable spirit unnecessary In animatism, the body and its indwelling life are not distinguished If the body be supposed to be subordinate to a separate animating principle, it is animism, in which the spirit uses the material as its vehicle Animism, implying a belief in spiritual things, is spiritualism or supernaturalism The Indians believed in an infinite and miscellaneous collection of spiritual entities[7] According to the degree of susceptibility of the individual and of the group, religious fervor fluctuated Whatever is new, usual, extraordinary or even useful, has in it some form of manifestation that engenders a religious feeling A South Sea Islander called a book 'god' because it talked by merely being looked at Red Jacket gave expression to a similar belief The primitive mind, being of rather unstable equilibrium, was readily swayed by slight occurrences that varied from the ordinary and, upon observing them, experienced a religious feeling

The prayers of the Indians were to the powers, but were not expressive of thanksgiving and gratitude for favors received They were a beseeching for favors anticipated Prayers were for the purpose of obtaining something, and were accompanied with offerings When the blessings were bestowed, they were not on account of any compassion of the power invoked, but in compensation for the gift The prayer and its answer were a kind of transaction in which offerings were bartered for blessings Soul and spirit, with primitive people, were interchangeably a manifestation of vital function. Their minds can not comprehend a thought without objectifying it in their senses This comes, sometimes, very near the materialization of spirits.

Early thought could not make distinctions that are so obvious to us Men, animals, plants and the inanimate world are much nearer their level than they are to ours. A mystic bond sprang up between individuals and groups on one side and a non-human object on the other side, which is the essence of totemism[8]

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[7] Marett, *The Threshold of Religion*, p 8.

While totemism was conspicuous among the Indians of the Northwest, it was feebly expressed in this locality, at least, it did not enter very much, if at all, into artistic expression No line of demarcation can be drawn, except theoretically, upon one side of which it can be said that all is animatism, animism, mana, magic, or pure religion and nothing else The conceptions blend along the borders The classifications are academic

It is very doubtful whether any Indian, unless he was reared from infancy among white people and disassociated from his own ancestral influences, ever grasped the missionary's religious point of view, or attained to a full conception of the fundamentals of Christianity The best he could do was to make an adjustment of Christian habiliments to the framework of his early conceptions It would be as difficult for an Algonquian to grasp the meaning of the word 'divine,' 'atonement,' 'trinity,' the significance of communion and baptism, and the forgiveness of enemies, as it would be for us to comprehend the Midiwiwin, manito, the sweat lodge, and the thunder-bird, and to work them into a complex consistent with our other cultural customs The Shako religion of Puget Sound is a very good illustration of an Indian's methods of adjustment of what he acquired as his social heritage and what he got from outside teachers It is an admixture of fundamental Indian beliefs, Catholicism and Congregationalism, and he finds it quite satisfying to his religious cravings[9]

The Indian had not a clear conception of a creator, because he supposed substance in some form always to have existed, especially the water and firmament Boas[10] points out that this is a marked difference from the Semitic belief, a fundamental of which was the objectifying of the universe by great creative energy.

Nowhere among our Indians was there a clear-cut formulation of a definite god-like being with definite powers and functions[11]

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[8] Hobhouse, *op cit*, p 347.

[9] Waterman, *Ann. Rept of the Smithsonian Institution*, 1922, p 499

[10] *Handbook American Indians — Religion.*

[11] Wissler, *The Indians of the Plains*, p 108.

The creation of something from nothing was no part of the Indian's belief

In connection with guardian spirits, one might read in the book of Acts about Peter, a certain man called Simon, also about Saul of Tarsus. The experience of Moses on Mount Sinai also comes to mind. When the spirits upon being importuned failed to give an agreeable response the cause ascribed was that the suppliants lacked concentration or intensity of will, or that the gift-offerings were inadequate The Indians did not have, and did not need, a devil — a master of evil The same spirit could be connected with good, 'no good,' and evil, which attributes were modes of the same functionary Dancing was a part of ceremonies and was frequently carried to the point of physical exhaustion, but dancing was not for pleasure or amusement It was ceremonial and ritualistic and associated with songs and bodily contortions With drums, rattle boxes and whistles they kept the rhythm of the time to the jumping, singing and whooping which were solemn performances and a kind of hysterical worship

Ceremonial festivals and feasts came at stated intervals They were held before, and sometimes after, corn-planting, harvests, and at the opening of the fishing and hunting season, and were regulated also by the heavenly bodies It is said that the wonderful Mexican calendars were not devised as a means for reckoning time, but as schedules for religious observances When great crises occurred, such as going to or returning from war, impromptu powwows were held, also the powwows were employed to ease the violence of storms, fires, pestilence, and other sudden acts of Providence Approaching and actual death called forth similar performances There was no thanksgiving day, in our sense, but almost innumerable days for supplication and sacrifice, which were really times for dickering with the powers, when sacrificial objects were 'put up' as a purchase price for favors Days of fasting often preceded the particular day when the ceremonial explosion was to come.

Magic, to which reference was made in another connection in this paper, is a fundamental element in the Indian's religion, although an objection is raised against including magic among religious concepts. Both the purely religious and the purely magical, if one does not include the other, mix together so much in the rituals that the compromise term magico-religious is sometimes used Medicine also was frequently an ingredient in the mixture The Fundamentalist will have no difficulty in grasping the magico-religious complex Among the many conspicuous examples of it are Aaron's rod, the scapegoat, restoration of the widow's son to life by Elijah, and the "hearing of a sound of a going in the tops of the mulberry trees"[12] There seems to be a similarity between spirits, as conceived by the primitive mind, and the vital force of the old physiologists

We find in Indian graves and mounds large numbers of implements of the hunt, of warfare and of personal adornment The Indian did not believe in the corporeal resurrection of stone axes any more than we do, but he believed that the stone axe had a spirit that could be of benefit to his own spirit Many of the articles taken from the graves are broken Grave pottery in some localities usually has a hole broken in the bottom This breaking of the grave deposits is called by archaeologists 'killing' The objects are killed to release their enveloped souls more readily for the use of the spirit The Indian might have understood transubstantiation Among some primitive people there was a habit of leaving a spirit hole in the grave

The priest, or whoever directed a ceremony, had to be familiar with all the rituals, formulae, routine and technical detail of his office A mistake in a dance, an error in the beat of a drum or in a song, a transposition of liturgy, betrayed ignorance and was liable to thwart the purpose of the ceremony A shaman also was confined to some ritual, but almost anyone might take up the 'healing art' and practice according to pranks of his own and become a medicine-man The medicine-man seems to have been a worthy forerunner of his modern successor, who has his special patients In fact there were specialists among the shamans One had more luck with the extremities, another with the head.

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[12] Exodus vii, Leviticus xvi, I Kings xvii, II Samuel v

Among the Ojibways and their affiliated tribes a grand medicine lodge was prominent and influential A preliminary preparation to 'join' the lodge was obligatory upon the candidates The name of this society was Midewiwin The ceremony consisted of four stages or degrees by which one was advanced from mystery to mystery and received progressively spiritual insight and power, especially power over disease A well qualified shaman was a graduate of this 'college.' He could practice ethically. Other practitioners were, according to the code, quacks While the medicine-men scoured the forests and fields for healing herbs, after all, it was the mystic element of the medicine and the grotesque performances of the practitioner that were believed to effect the occult cures

The question, of course, is raised as to the conscientiousness of priests, conjurers and doctors How could they be sincere? The answer is, at least in part, that their powers of reasoning were no more expanded than their general cultural level allowed They were no more deceptive than their corresponding professions are with us There were some impostors and charlatans, but the majority of the priesthood and physicians believed in what they practiced and preached Primitive man was credulous and the laity had wonderful confidence in their specialized cults If magic failed a medicine-man, the explanation was easy and always accepted Some more powerful magician or power was working against it, which, if it could be neutralized or overcome, would surely subside and the case in hand would terminate as the operator had prognosed.

The word *manito* among the Algonquians, *orenda* among the Iroquois, and *wakenda* among the Siouan tribes signify a detachable property of the great power that becomes transferred to an object The property becomes indwelling in the object either permanently or temporarily and becomes manito. Any thing, animal or person which had unusual appearance or behaved in a manner so as to attract particular attention was said to have manito A rock, as cited before, rolling down a steep declivity breaking down bushes or doing damage is an illustration. A person who displayed unexpected skill, bravery or sagacity which resulted in a happy termination at the time of great peril or stress, had manito If he sacrificed his life, or paddled a canoe safely through turbulent rapids, or was lucky in fishing, he was, for the time, at least, saturated, so to speak, with manito The sweat lodge was an important part in the preparation for many 'services,' especially those of a religious nature If the one taking the sweat came out feeling invigorated, he said it was manito that had come into him through the agency of the steam and vapor Manito was to an Ojibway what the Holy Ghost was to Saint Luke, who is accredited with the authorship of a monograph entitled the Acts of the Apostles Probably in our day, or a comparatively short time ago, many people would have accounted for the unusual actions or accomplishments by saying that the hero is 'possessed'

It cannot be said that the Indian had idols, they were not idolators While they had vague conceptions of some mystic and nebulous deities, they did not raise themselves to the high conception of a specific spirit that remained localized The Indian brought his emblems down to his own level and made them brutally human The religion of savages was not thought out It developed under excitement, emotion and motor stimulation Perhaps the priests and shamans exercised a feeble directing influence in forms, but not in concepts Such religion may, comparatively speaking, be said to be rudimentary

Whatever was mysterious and considered accordingly was within the religious pale Animism, which signifies belief in the activity of spirits and visionary shapes is the central idea of the religious practices of the American Indians and of all other peoples of the same cultural level The Indians of the Great Lakes region, if not of the entire American continent, having no personal deities whose names they could take in vain, were unqualified for expressing their wickedness by profanity They could not make or take oaths, for there was no one to swear by They bound their contracts and plighted their honor, so far as they had any, by means of the calumet, strings of wampum and sacred tobacco.

The Indian probably believed in an existence after death He had a confused conception of independent spirits, spirits of people and things, and ghosts who wandered about presenting themselves in dreams and whispered in the ears of neurotic priests, shamans and medicine-men. Spirits often flitted about in the guise of owls. Among some other peoples, bats, doves and other flying and floating objects were believed to be spirit-bearers.

Not every spirit after death successfully hit the trail for the fields of contentment where he could become naturalized. With some tribes the trail was tortuous, dangerous, and led to a kind of second death for those whose shrewdness did not succeed in crossing the barriers, and in eluding the wayside dangers. Spirits for a time frequented the places where their former earthly tabernacles were deposited. The friends would put food by the bodies and upon graves for the spirits. The fact that the substance of the food was unconsumed was no proof of the uselessness of placing it there. The spirits partook only of the spirit of the food. The substance would, of course, be left and might be eaten afterwards by the depositors as its transubstantional properties would be gone.

At the feasts of the dead, among some, if not all the Lakes Indians, the family made lavish gifts, somewhat like a potlatch. This expenditure only, Perrot[13] says, can fully secure rest and respect in the land of spirits. Taylor[14] states that nothing but dreams ever put into men's minds such an idea as that of souls being ethereal images.

Changes in religious conceptions may be traced progressively through animatism, anthropomorphism, polytheism to monotheism. The Indian never ascended to real polytheism, but some of his spirits were anthropomorphic.

The question may be raised, What is the use or gain to us in studying these primitive traits? We are not savages, our religion is nothing like that. If such a question deserves an answer, a partial reply is that the stratum of society in which the religious concepts such as I have tried to portray, using the American Indian almost entirely as a type, is that through which our own antecedents passed sometime, somewhere in the remote past, and to obtain a continued record of social, intellectual, and religious development, we must incorporate all the facts in the history

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[13] *Indian Tribes of the Upper Mississippi and the Great Lakes Region* I 88

[14] Quoted by Lowie, *Primitive Religions*, p. 107.

From the standpoint of science, such studies are in the class with that other field of investigation that includes the study of rocks in the search for fossils. Many of the primitive races are extinct, in fact, the vast majority of them are forever gone. So to speak, they are fossilized The remaining groups are pretty rapidly approaching the stage of fossilization.

There are, in the broad survey of man's past, two objects for intensive work, the historical and the purely scientific, if a distinction may be made between these fields The methods of history and of the field-worker find ample opportunity in unraveling the records of the remote past, to use the word 'remote' both *in its ethnological and the ordinary sense* From the credulous savage who believes the whirr of the bull-roarer to be the voice of a powerful spirit up to Christianity, there can be traced the slow development of religious concepts as they became clarified by the introduction of moral and charitable elements The development of religion has somewhat of an analogue in what science calls evolution.

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# THE PROTECTIVE POWER OF RED

HERBERT A. KENYON

COLOR symbolism has long held an attraction for folklorists However, the greater part of the data on the subject consists of notes and statements of the use of certain colors in more or less isolated instances, or merely incidental citations The present paper ventures to bring together a number of cases of the use of red as a protective power and to attempt an explanation of its widespread use both geographically and historically

What is probably the earliest example of its use for this purpose is found in the Old Testament The Children of Israel are ordered in the twelfth chapter of Exodus to select a lamb, kill it in the evening, and "take of the blood and strike it on the two side posts and on the upper door post of the houses — for I will pass through the land of Egypt this night and will smite all the first born both man and beast — and the blood shall be for a token upon the houses where ye are and when I see the blood I will pass over you and the plague shall not be upon you to destroy you when I smite the land of Egypt "[1]

Of course here we have the protection indicated as promised to the marked houses However, it is but a step from promised protection to the plea for protection through execution of the prescribed formula.

We cannot be concerned too deeply with particular shades of red Early peoples distinguished but little between tints or shades of a color and modern peoples almost as little where magic or occult power is concerned. For the purpose of our discussion we may consider the pinkish color of a certain type of coral or the deep purple of dried blood as red

The universality of the belief in the protective power of red is one of its most interesting features. In practically all

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[1] Exodus xii. 3, 7, 12, 13

European countries, in China and India, among the most inaccessible tribes of Africa and among the American Indians, throughout the ages, from the *trabea* of the Salii and the Roman augurs[2] to the red flannel underwear to prevent rheumatism of the preceding generation, red has spread its protecting influence. The material does not seem to have any particular importance. Bits of cloth, ribbon, paper, string, or costly jewels are equally efficient so long as the predominating color is red. Sometimes as in red agate[3] and the bloodstone,[4] there is a combination of color, but the important properties appear to be inherent in the red portion or red coloring.[5]

But let us examine for a moment what sort of protection has been afforded by red. It is a preventive against witchcraft, the evil eye, charms, etc. In Spain,[6] Italy[7] and the Orient, coral is used for amulets. In China when a man has a bad dream, to avert the impending calamity he is presented with a mystic scroll written on red paper.[8] In London houses horseshoes, covered with a red cloth, were hung over beds to keep the occupants from suffering from nightmare. In Ireland red tape was used around the children's necks to prevent an attack of the plague, the only prophylactic use I have ever heard of for red tape.[9] Among the Arabs of Arabia Petraea coral is worn by almost every man and woman as an amulet against the evil eye.[10] A fragment of a Greek lapidary, probably of the fourth or fifth century, gives a list of amulets for sailors, a carbuncle was prescribed to protect from drowning, coral was to be attached to the prow of ships to guard the vessel from wind and waves in all waters[11] In the Leyden papyrus the bloodstone is praised as an amulet that will "assuage the wrath of kings and despots" and it declares that "whatever the wearer says will be believed "[12]

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[2] Armstrong, Mary E., *The Significance of Certain Colors in Roman Ritual*, p. 4, quoting Dion. Hal., 2 70, and Helbig, *Sur les attributs des Saliens*, p. 56.

[3] Psellus, *De Lapidum Virtutibus*, ed. Bemond, p. 10.

[4] Monardes, *Simplicium Medicamentorum ex Novo Orbe Delatorum Historia*, Lat. version by Clusius, Antwerp, 1579, p. 51, also cf. Bernadino de Sahagun, *Hist. Gen. de las Cosas de Nueva España*, Vol. III, Lib. XI, Cap. VIII, pp. 300, 301, *Journal of American Folk Lore*, Vol. IV, p. 30, Belucci, *Il Feticismo in Italia*, p. 91, note.

[5] Theophrastus, *History of Stones*, w. Eng. version by John Hill (London, 1746), p. 73.

[6] Antonio Machado y Alvarez, *Biblioteca de Tradiciones Populares Españolas*, Vol. 8, p. 258.

[7] Hardwick, *Traditions and Superstitions*, p. 255.

[8] Stauffer, *The Queer, the Quaint and the Quizzical* (Phila., 1882), p. 225.

[9] Stauffer, *op. cit.*, p. 339.

[10] Kunz, *Magic of Jewels and Charms*, p. 346.

The Lapidario of Alfonso X recommends the wearing of the carnelian to those who have a weak voice or are timid in speech, for the warm-colored stone will give them the courage they lack[13] An Armenian writer of the seventeenth century declares that the wearer of a carnelian is proof against being harmed by falling houses or walls[14] Albertus Magnus says that the bearer of coral could still the tempests and travel in safety[15] In India rubies served to remove evil thoughts and control amorous desires and reconcile disputes[16] The ruby in Burma[17] was supposed to confer invulnerability. Zachalias Babylonius recommended to Mithradates the use of hematite for soldiers suffering from loss of blood in battle[18]

The virtues of red apply even to animals In Aberdeenshire it is a common custom for the housewife to tie a piece of red worsted thread around the cows' tails before putting them out to graze in order to protect them from the evil eye, elf shots, and other dangers[19] In the first century in Rome, dog-collars set with flint and Maltese coral were recommended as a cure or preventive of hydrophobia This was probably due to the belief that hydrophobia was caused by the evil eye Gratius Faliscus states that if such collars were put on dogs suffering from hydrophobia, the gods were appeased and the charm cast by the evil eye was broken[20]

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[11] Kunz, *Curious Lore of Precious Stones*, p 38

[12] Kropatschek, *De Amuletorum apud Antiquos Usu*, p 16

[13] *Lapidario del Rey Alfonso X*, codice original, Madrid 1881, folio 77, p 49.

[14] Kunz, *Curious Lore of Precious Stones*, p. 63

[15] Albertus Magnus, *Le Grand Albert des Secretz des Vertus des Herbes, Pierres et Bestes, etc* Turin (c 1515) Liv II, Fol 9, recto

[16] Kunz, *Curious Lore of Precious Stones*, p 102 ff

[17] Kunz, *op cit*, p 103

[18] Pliny, *Natural History*, Lib XXXVII, 60

[19] Hardwick, *Traditions and Superstitions*, p. 138.

The protection may extend even to inanimate things. A red cloth is laid over a churn when butter is being made to prevent the milk from becoming bewitched and yielding no butter

Inasmuch as primitive medicine and primitive cures for diseases were based upon the idea that the sufferer was possessed by evil spirits, it is not surprising to find that a color which plays so important a rôle in the prevention of evil influences should be used in the prevention and cure of disease

In medicine we have two uses of red, one where the color gives the therapeutic quality, and the other its use as sympathetic or homeopathic magic Sometimes these two uses coincide and it is difficult to draw a clear line of demarcation.

In the West Indies a little bit of scarlet cloth, no matter how small, worn around the neck will keep off the whooping cough[21] John Wesley in his *Physick* states that the ashes from a crimson cloth should be blown upon a cancer of the tongue

Red string, red stones, anything red has been used to stop hemorrhages or to prevent nose bleed[22] Warts may be cured in Kansas to this day by putting into a bag of red calico hearts from grains of corn The patient is ordered to run down the road and throw the bag away without seeing where it falls[23] When the bag is found the warts will be transferred to the finder. Erysipelas is cured in Mexico[24] and among the Pennsylvania Germans[25] by limiting the extent of the rash or measuring its extent by a red string or red woolen yarn. In Kentucky, rheumatism is treated with red-worm oil[26] and in many a New England home it was prevented by the wearing of red flannel underwear, and when that was no longer attainable by the sewing of a piece of red flannel into a white undershirt

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[20] Gratius Faliscus, *Cynegeticon*. Collec des Auteurs Latins, ed. Nisard, Vol XVI, p. 786, ll. 401, 405

[21] W G. Black, *Folk Medicine, Publications of Folk Lore Society*, 1883, Chapter VII.

[22] *Journal of American Folk Lore*, Vol. IV, p. 153, Vol. VII, p. 187, Vol. XI, p. 132, Vol XII, p 47.

[23] *Op cit.*, Vol XI, p. 29.

[24] *Op. cit*, Vol. XXXVI, No 140, p 200.

[25] *Op cit*, Vol X, p 78.

[26] *Op cit*, Vol. XIV, p. 32.

Pettigrew in his *Superstitions Connected with the History and Practice of Medicine* says "In small pox, bed coverings of red were employed with the view of bringing the pustules to the surface of the body "[27] When the son of Edward II was sick of the small pox, John of Gaddesden directed that the bed furniture should all be red and a Japanese writer tells us that when the children of the royal house were attacked by small pox, they were put in rooms where bed and wall were alike covered in red and all attendants were clothed in scarlet[28] The bloodstone, the garnet, and the carbuncle were practically specific in blood diseases in the practice of medicine in the Middle Ages In China to the present day red cloth is worn in the pockets for the prevention of disease, red silk is braided in the hair of children and charms are written on red paper[29] In a Chinese tale, red pills are administered. In one case the pill was passed round and round to cure the wound and in another to restore life it was placed in a man's mouth — with great success — according to the story[30] Among many tribes of the American Indians red or a red feather is the distinguishing mark of the medicine man, as well as of many of his medicines[31] Examples of the use of medicines where apparently the curative power lies in the color could be quoted in profusion but these will suffice.

Another phase of the outstanding importance of red is seen in its use as a royal color, for we may consider purple as a later development of the same idea Indeed, in primitive tribes the king, the medicine man, the chief, the ruler is almost always distinguished by something of a red hue — the red umbrella of the Eastern potentate and the red feather of the magician of the

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[27] *Ibid.*, pp 18–19

[28] W. G Black, *Folk Medicine, Publications of Folk Lore Society*, 1883, Chapter VII

[29] Dennys, *Folk Lore of China*, p 54

[30] Giles, *Strange Stories from a Chinese Studio*, Vol I, pp 40, 44, 45

[31] *Journal of American Folk Lore*, 1884, p 190, Vol VII, p 109, Vol. XIII, pp. 4 and 5.

Micmac Indians are manifestations of the same idea [32] The red feather cape of the Hawaiian rulers and the red breech cloths and ceremonial aprons of negro tribes give evidence of the widespread belief in the sacredness attached to the color.

In the animal world those of a noticeably red color have always enjoyed particular distinction This distinction frequently reaches the point of veneration, particularly when there is a symbolic meaning attached to the animal [33] In the Vedas the dawn is symbolized by the goddess Ushas and the ruddy light in the east which precedes sunrise was regarded as a herd of red cows attendant upon her [34] This again suggests the oxen of the sun in Homer Red is especially mentioned as the color of the heifer set apart for the sacrifice in the purification of sin in the Old Testament [35] and scarlet is signified as one of the articles to be cast into the midst of the burning heifer [36] The milk of red cows is an important element in the recipe for the cure of consumption in Dr Samuel Jones *Medicine Boke* published in the later part of the seventeenth century [37]

Birds of a conspicuously red color have borne a more or less sacred character from time immemorial The robin, the woodpecker, the red-legged stork, the cardinal bird have all enjoyed a special sanctity [38] Of the birds used in classical augury one of the most important was the woodpecker [39] Hence it was connected with Jupiter and was as well sacred to Mars.

Through the conspicuously red birds and the reason why they were held in especial veneration we get the real clue to the significance of the power of red Fire was the greatest mystery to primitive man next to life itself. These birds were the legendary fire-bringers — the lightning birds — and so were sacred to the highest of the gods, and represent him in both the terrifying and beneficent aspects Fire was a gift of the gods but it was an awesome weapon as well in the thunderbolt In pagan tradition we have woodpeckers and other red birds as fire-bringers — sacred to Jupiter Fulminator It was most natural for primitive man to make a bird the connecting link in the bringing of fire to earth from the heavenly abode of the gods

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[32] *Op cit*, Vol. IX, p 173

[33] *Op cit*, 1884, p. 31, M Bloomfield, *Hymns of the Atharva-Veda*, p 7 ff, 263 ff

[34] Hardwick, *Traditions and Superstitions*, p 112.

[35] Numbers, xix. 2.

[36] Numbers, xix. 6.

[37] Hardwick, *Traditions and Superstitions*, p. 112

[38] *Ibid*, pp. 136, 149, 242.

[39] Armstrong, *Significance of Certain Colors in Roman Ritual*, p. 6

Miss Armstrong in her doctors's dissertation on *The Significance of Certain Colors in Roman Ritual* has shown that the use of red there is clearly derived from this association with fire In medieval and later tradition we see the stork as a protector from fire and lightning of the house on which it builds its nest In Christian legend red birds gained their conspicuous color from being wounded by the crown of thorns[40] Here again is the explanation of the color from its connection with deity changed to suit the changed ideas of a god And just as the Picus Martius of the Romans became sacred and was used by Roman augurs, so the stork and the robin became sacred and protected birds in Christian tradition From its association with deity, red became representative of deity and hence is the symbol of majesty in kings as a representation of the divine power. It represents the power of the god in its most obvious form of fire and so is used to attract or propitiate him And finally from the attribute of the god as a divine healer it gains its power in medicine As red is the color of fire and the thunderbolt, it is only logical that primitive man and his less primitive but more or less blindly imitative successors should adopt it as the color having the greatest magical properties From this association with divinity, the color itself becomes divine and so exercises the powers of the god.

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[40] Frazer, *The Golden Bough*, Vol. I, pp 79–82

# LONGEVITY AND REJUVENATION IN GREEK AND ROMAN FOLKLORE

EUGENE S. McCARTNEY

## LONGEVITY

IN the Homeric *Hymn to Aphrodite*[1] old age is described as wearying, ruthless, deadly, and as dreaded even by the gods. Many such adjectives are applied to it by Greek writers, especially by Theognis. Baneful old age is one of the offspring of deadly Night, says Hesiod.[2] In Latin one author calls old age a disease[3] and another goes farther and regards it as an incurable disease.[4] To most old men, Cicero tells us, it seems a "burden heavier than Etna."[5] Cicero tried to gain courage to face it by writing an essay on the subject. In antiquity old age was, I believe, much harder to bear than it is today.[6] It is now no longer sans teeth, sans eyes, sans taste, sans everything.

In the Golden Age the earthly paradise of man was free from disease[7] and wretched old age rested not upon him, for when he died it was as though he were overcome with sleep.[8] In Homeric days the sudden death of a man without sickness was ascribed to the 'painless shafts' of Apollo,[9] while the similar death of a woman was attributed to Artemis.[10] Nowhere in classical literature are 'unagingness' (= youth) and deathlessness more fondly idealized as the greatest felicity of mankind than in its earliest remains, Homer and Hesiod. Hector [11] reflects "If I were deathless and unaging . " Sarpedon [12] thus communes with his friend Glaucus "O good sir, if we escaping this war were going to be always unaging and deathless, never would I fight in the van and place you in the man-ennobling battle"

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[1] 245–247.

[2] Theognis, 224–225.

[3] Terence, *Phormio*, 575.

[4] Seneca, *Ep.*, 108. 28.

[5] Cicero, *Cato Major*, 4.

[6] For the attitude of some of the classical writers toward old age see pages 116–118 of an article by Cornelia G. Harcum, "The Ages of Man," *The Classical Weekly*, 7: 114–118. For an especially gloomy picture see Juvenal, 10. 188–288.

[7] Hesiod, *Works and Days*, 90–92.

[8] *Op. cit.*, 110–120.

[9] *Il.*, 24. 759, *Odyss.*, 3. 280, 7. 64, 15. 411, 17. 251, 494.

[10] *Il.*, 6. 428; 19. 59; 21. 483, *Odyss.*, 5. 124; 11. 173, 199, 324; 15. 411, 478; 18. 202, 20. 80.

Calypso tries to lure Ulysses to her wishes by promising to make him immortal and unaging [13] In Hesiod [14] it is said that out of regard for Dionysus escape from death and old age was provided for Ariadne Hesiod regarded Heracles as happy when he had finished his work among mankind and with the gods was passing his days untroubled and unaging [15]

Thetis wanted to make Achilles deathless and unaging [16] In nothing, perhaps, was Zeus more to be envied than because he was a ruler to whom time brought not old age [17] Tros, the father of Ganymedes, grieved over the disappearance of his son, but when Zeus sent him a message saying that his son would be immortal and ageless like the gods, he ceased his mourning and rejoiced in his heart [18] Calypso, too, was immortal and unaging [19] The goddess Hebe, it will be recalled, was a personification of youth

After the Golden and Heroic ages, peoples and persons distant in space rather than in time were regarded as endowed with special boons There are several traditions of tribes and individuals who were able to arrest the hand of Time and to live a long life without aging and without suffering the physical and mental effects of longevity, a blessing second only to immortality

In certain places in India where there was no shade men grew to be exceedingly tall and lived one hundred and thirty years without becoming old, but died in middle life, as it were.[20–21]

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[11] *Il*, 8 538–539

[12] *Il*, 12 322–325.

[13] *Odyss*, 7 257 Cf 5 209.

[14] *Theog*, 947–949

[15] *Op cit*, 954–955

[16] Apoll Rhod, 4 869–870

[17] Soph, *Antig*, 609–611.

[18] *Homeric Hymn to Aphrodite*, 202–217.

[19] *Odyss*., 5. 218

[20] Pliny, *Nat Hist*, 7 28

[21] In the Silver Age children played a hundred years by their mother's side before reaching maturity, but they lived only a short period afterwards. — Hesiod, *Works and Days*, 130–139

According to Pindar,[22] the Hyperboreans suffered neither from disease nor the ravages of old age Other writers state that they were a long-lived race,[23] that they lived a thousand years,[24] that death did not come until they had had their fill of life and enjoyed a luxurious old age, at which time they threw themselves into the sea [25]

Zoroaster lived thirty years in solitudes upon cheese prepared in such a way that he was insensible to the advances of old age [26] The fabulous medieval Prester John tells us that "A fountain flows from Mount Olympus not three days' journey from Paradise whence Adam was expelled Three draughts from it taken fasting insure one henceforth from all infirmity, and however long one may live, one will seem henceforth but thirty years of age " [27]

Another extravagant tale is told of an island "somewhere off the west coast of Ireland," Tirnanoge, "Land of Youth," where the hero Oisin lived three hundred years without loss of youth of strength [28] Astrology too taught that man was originally long-lived He lived longest during the thousand years of the dominancy of the planet Saturn His span of life gradually decreased during the six millenia that were assigned to the other planets [28a]

Some of the ancients did not believe a happy long life possible Mimnermus [29] expresses a wish that he may live his life free from disease and care and that death may overtake him in his sixtieth year According to tradition the people of Cos were not content with wishing They decided that those who could not live well should not live ill There is a tradition that they passed a law providing that sexagenarians should take hemlock.[30] According to another writer it was customary for people on reaching sixty years of age to summon their friends as if to a sacrificial feast and then with garlands upon their heads to drink the fatal draught.[31] Hellanicus [32] states that the Hyperboreans themselves took their sexagenarians outside the gates and made way with them Seventy was the age the Sardinians allowed their old men to reach before thrusting them over a cliff amid laughter [33]

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[22] *Pyth* , 10 41–42 (65–66) [23] Callimachus, *Hymn IV*, 282

[24] Strabo, 15 57

[25] Pliny, *Nat. Hist* , 4 89, Solinus, 16 4–5, Pomp Mela, 3 5 2 See too Martianus Capella, 6, p 228 (ed Eyssenhardt)

[26] Pliny, *Nat Hist* , 11 242

[27] Lynn Thorndyke, *A History of Magic and Experimental Science during the First Thirteen Centuries of Our Era*, II 242 See also note 2

[28] See P W Joyce, *Old Celtic Romances*, pp 385–399, 410, and also Mary Lyons Hennigan's article on "Tir-na-n'og" in the *Atlantic Monthly*, May, 1925, pp 637–644

[28a] *Catalogus Codicum Astrologorum Graecorum*, 4. 114–115.

[29] Bergk, *Poetae Lyrici Graeci*, Frag 6

When one of the Massagetae became exceedingly old, all his relatives gathered together and made a sacrificial offering of him, and killing animals along with him they boiled the flesh and feasted and made merry If a man died of disease, they did not feast upon him, but concealed him in the ground, taking it as a misfortune that he did not live to be sacrificed.[34] Tradition says that the Derbiccae killed men over seventy years of age and strangled their wives.[35]

While there are many records of historical characters who attained the proverbial ripe old age,[36] we are interested chiefly in fabulous and extravagant accounts Nestor is reported to have lived through three generations of mortal men [37] The life of Tiresias was prolonged by Zeus to seven [38] (or nine [39]) times that of mankind in general [40]

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[30] Strabo, 10 5 6

[31] Ael., *Var. Hist*, 3. 37.

[32] Ap Clem Alex, *Strom*, 1 15 33–35.

[33] Tzetzes, *ad Lyc Alex*, 796 See too Ael, *Var. Hist*, 4 1

[34] Herod, 1 216

[35] Ael, *Var Hist*, 4. 1.

[36] Pliny, *Nat Hist.*, 7 156–163, Lucian (?), *Longaev*, Cicero, *De Senectute*; Censorinus, *De Die Natali*, 15, Valerius Maximus, 8. 13, Phlegon, *Longaev* (= Müller, *Frag. Hist. Graec*, 3 608–611)

[37] *Iliad*, 1 250, *Odyss*, 3. 245.

[38] Hesiod, Frag 161 (189) Phlegon, *Mirabilia*, 4 (Müller, *op. cit.*, 3. 618), Hyg, *Fab*, 75; Lactantius Placidus on Statius, *Theb*, 2. 75, Second Vatican Mythographer, 84 (in *Scriptores Rerum Mythicarum Latini*, ed. Bode), Tzetzes, *ad Lyc Alex*, 682

[39] Tzetzes, *loc. cit*, records also the tradition of nine generations.

[40] Together with Apollo Zeus extends the life of Phalaris two years. —Ael., *Var. Hist.*, 2. 4.

Pliny collected a number of instances of fabulous longevity in his *Natural History*[41] He records that Arganthonius,[42] king of the Tartesii, is said to have lived 150 years, Cinyras, a Cyprian, 10 years more, Aegimius, 200 years, Epimenides, the Gnosian, 157 years,[43] some tribes of the Epii in Aetolia, 200 years, Pictoreus, a man of remarkable physique, 300 years, certain kings of Arcadia, 300 years, Dandon, an Illyrian, 500 years, the king of the Lutmii, 600 years, his son, 800 years, an age that rivals Methuselah's

Josephus gives Hesiod and five other Greeks as authorities for his statement that 'the ancients' lived one thousand years[44]

At the time of her meeting with Aeneas the Cumaean Sibyl was 700 years old and still had 300 more to live[45] In an inscription of Erythrae she says that she is 900 years old,[46] a rather startling admission for a woman. It was stated by an oracle that she was to live through ten generations of men[47] The length of her life was surpassed by "the fair-tressed nymphs, daughters of the aegis-bearing Zeus," who lived ten times the life of the phoenix[48] The demons lived 9720 years[49] In Sir Rider Haggard's story, *King Solomon's Mines*, Gagool, "the wise and terrible woman who does not die," is represented as having lived for generations.

There were entire nations whose people were said to enjoy long life One tradition states that Europe, Asia and Libya were islands, and that beyond them was a continent where men were twice as tall and lived twice as long as other men[50] Isogonus informs us that a people of India, the Cyrni, lived to be four hundred years old. He believed the same thing to be true of the Ethiopian Macrobii ('Long-Livers'), the Seres and the inhabitants of Mount Athos.[51] The Hyperboreans have already been mentioned. Other illustrations of long-lived tribes will be given in other connections.

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[41] 7 154–155 Cf Augustine, *De Civ Dei*, 15 12

[42] Cicero, *De Senectute*, 16 69, and Herod, 1 163, say 120 years, Pliny, *Nat. Hist*, 7. 156, says 130 years, Valerius Maximus, 8 13, *Ext* 4, and Censorinus, 17 3, say 150 years

[43] His years of life are variously given as 154, 157 or 299, according to Diogenes Laertius, 1 10 4

[44] *Ant. Iud*, 1 3 *ad finem* See Euseb, *Praep Evang*, 9 13

[45] Ovid, *Met*, 14 144–146 Cf *longaeva sacerdos*, Verg, *Aen*, 6 321, 628

[46] See Pauly-Wissowa, s v *Sibyllen*, p 2085

[47] Phlegon, *Longaev*, 4(= *Frag Hist. Graec*, III 610) See Aristotle (?), *De Mirab. Ausc*, 95, p. 838 a 5.

[48] Hesiod, Frag. 171 (183).

[49] Plut, *Mor*, 415 D

[50] Theopompus, in Mueller, *Frag Hist Graec*, I 290.

The idea of extending one's days by magical means is not very common. A complex preparation consisting chiefly of 'mountain squill,' selected and prepared in accordance with certain definite restrictions, is said to have been employed by Roman emperors to prolong their lives. Pythagoras, its original compounder, started to use it at the age of fifty, and lived free from disease till he was one hundred and seventeen years old. The account says that Pythagoras was a philosopher and that he could not lie.[52]

Another way to attain fulness of years is by eating the flesh of animals tenacious of life. Some Roman women of princely rank partook of venison every morning and lived a long life free from fevers.[53] The ostensible reason here is immunity from fevers, since the deer was supposed not to be susceptible to them, but nevertheless there is some emphasis on long life. A clearer illustration is to be found in the story of Medea's restoration of youth to Aeson. She infused into his veins a decoction containing among other things the liver of the long-lived deer,[54] the skin of a snake, and the head of a crow that had lived nine generations[55] The long life of the inhabitants of Athos was attributed to their using the flesh of vipers as food[56–57]

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[51] Ap. Plin., *Nat. Hist.*, 7. 27.

[52] Galen, XIV. 567 ff. (ed. Kuhn).

[53] Pliny, *Nat. Hist.*, 8. 119, Solinus, 19. 17.

[54] To determine the duration of the life of the deer Alexander the Great put golden bands ('necklaces,' according to our informants) upon a number of them. More than a hundred years later they showed no signs of old age, according to Pliny, *Nat. Hist.*, 8. 119, Solinus, 19. 18. Epiphanius (?), *Physiol.*, 5 (Migne, *Patrol. Graec.*, 43. 521) says that the life of the deer is fifty years. Silius Italicus, 13. 124–129, represents one deer as living 1000 years.

There are many references to the longevity of the deer: *vivacis cervi*, Ovid, *Met.*, 3. 194, 7. 273, *idem*, *De Med. Fac.*, 59, Verg., *Ecl.*, 7. 30, *Anthol. Lat.*, No. 779, line 115 (ed. Riese), *longa et cervina senectus*, Juv., 14. 251. See too Cic., *Tusc. Disp.*, 3. 69, Pollux, 2. 16, Oppian, *Venat.*, 2. 291–292. The deer was believed to be longer lived than the elephant (Paus., 8. 10. 10).

## *Longevity of Animals*

The eagle, too, was long-lived, according to popular belief Both Greeks[58] and Romans[59] typified longevity by the expression, "an eagle's old age" "The old age of the eagle the lark's youth," was a Greek proverb[60] A Greek writer exhorts an emperor to live the long life of the eagle, ever renewing his youth and strength[61]

There are many passages which attribute to the crow a life of nine generations[62] Phaedrus[63] assigns to it one thousand years of life 'To live a crow's age,'[64] 'to outlive the crows,'[65] 'to live out the second crow,'[66] and similar expressions became commonplaces to indicate a long life One long-lived man is picturesquely described by a late Byzantine writer as competing with crows of 'unmeasured lives'[67]

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[55] Ovid, *Met*, 7 272–274

[56] Plin, *Nat Hist*, 7 27

[57] "The Indians and French Canadians in Vermont eighty years ago fried and ate rattlesnakes to secure long life" — Bergen, *Animal and Plant Lore*, p 70

[58] On the long life of the eagle, see Aristotle, *De Anim Hist*, 9 32 619 b.

[59] Ter, *Heaut Tim*, 521, Aus, Book V (*Prof*), 4 22

[60] See Suidas, s vv 'Αετοῦ γῆρας

[61] Phile, *Versus de Animalium Proprietate, 1 De Aquilis*

[62] Hesiod, Frag. 171 (183), Ovid, *Am*, 2 6 35–36 (*saeclis novem*), *idem, Met*, 7 274, Arat, *Phaen*, 1022 (*ἐννεάγηρα κορώνη*) See too Hor, *Carm*, 3 17 13 (*annosa cornix*), Lucret, 5 1084 (*cornicum ut saecla vetusta*), Juvenal, 10 1046–1047 (*Pylius exemplum vitae fuit a cornice secundae*), Mart, 10 67 5 (*iam cornicibus omnibus superstes*), Cic, *Tusc*, 3 69, Ausonius, Book VII, *Ecl* 5, *Anthol Lat*, No 286, line 96 (ed Riese), Sen, *Ben*, 2 29 1 Aristophanes, *Aves*, 609 (cf 967), mockingly gives its life as five generations

[63] *Appendix*, 24 7 So too Ausonius, *Epist*, 18 24

[64] *Greek Anthol*, 11 361 7 *βίον ζώοιτε κορώνης*

[65] Pollux, 2 16 (= *Com. Anon*, 4 680, ed Meineke)

[66] Babr, *Fab*, 46 9 *κορώνην δευτέραν ἀναπλήσας* Cf *Greek Anthol*, 5 289 *ἡ γραῦς ἡ τρικόρωνος*; 11. 69 *Θεμιστονόη τρικόρωνος*, 11 67 *κορωνεκάβη*

[67] Constantinus Manasses, *Comp Chron*, 6333.

The age of the phoenix has been given with great explicitness and variety by ancient authorities as 500,[68] 540,[69] 1000,[70] 1461,[71] and 7006[72] years 'To live the years of the phoenix,' became proverbial for longevity[73–74]

The most famous passage with regard to long-lived animals is a fragment of Hesiod[75]

"Nine generations of aging men doth the chattering crow live,[76] four times as long as the crow liveth the stag in three lives of the stag the raven groweth old while the phoenix liveth ten times as long as the raven and ten times as long as the phoenix live we, the fair-tressed nymphs, daughters of Zeus, the Lord of the Aigis"[77]

According to this the crow lives nine times as long as man, the stag, 36, the raven, 108,[78] the phoenix, 1,080, while the nymphs live 10,800 times as long This passage is quoted in part or in whole many, many times by ancient writers, both Greek and Roman[79] Ausonius made the most effective use of it in his *Riddle of the Number Three.*

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[68] Herod, 2 73, Philostr, *Apollonius of Tyana*, 3 49, Ovid, *Met*, 15 395, Tac, *Ann*, 6 28, Hieronym, *Epist ad Praesid* (= Migne, *Patrol Graec*, 30 187), Clem Roman, *Ep ad Corinth*, 1 25, *idem, Const Apostol*, 5 7 (= Migne, *Patrol Graec*, I 846)

[69] Plin, *Nat Hist*, 10 4, Solinus, 33 12

[70] Ausonius, Book 18, *Ep* 24; Nonnus Dionys, 40 395, Pliny, *Nat Hist*, 29 29, Lactantius, *De Phoenice*, 59

[71] Tac, *Ann*, 6 28 See also Bochart, *Hierozoicon*, Part II, p 817.

[72] Tzetzes, *Chil*, 5 387 ff

[73] Luc, *Hermot*, 53 Cf *Sic tibi phoenicis transcendere congruat annos* (*Anthol. Lat*, No 254, ed Riese)

[74] For other references see Ovid, *Am*, 2 6 54 (*vivax phoenix, unica semper avis*), Sen, *Ep*, 42 1; Tac, *Ann*, 6 28; Statius, *Silv*, 2 4 36, Aur. Vict, *Caes*, 4 12, Claud, *De Cons Stil*, 2 414–417, Luxorius, in *Poetae Latini Minores, Epig*, 697 2

[75] 171 (183) [76] In our own lore the cat has nine lives

[77] A W Mair's translation, p 98

[78] According to tradition, "Edgar," a coal black raven living in the Tower of London, saw the earl of Essex executed some 300 years ago. A newspaper clipping says that at all events he has been at the Tower as long as the present generation can trace

[79] Plut., *Mor*, 415 c, Pliny, *Nat Hist*, 7 153; Ausonius, Book 7, *Eclogue* 5 Many quotations from it or references to it are collected by Rzach, *Hesiodi Carmina*, pp. 382–383.

"Thrice was the distaff of Nestor's destiny replenished with purple yarn, and as many times doth the crow outlive that triple span And could she roll into one nine times the periods of three ages, yet by thrice Nestor's triple span do brazen-footed stags surpass her, whereof three lifetimes does the sacred bird of Phoebus overpass, to be nine times outstripped by that fowl of Ganges, radiate of head within his nest of cinnamon "[80]

### *Immortality upon Earth*

The yearning of people to remain upon this earth was not limited to a long life or even to a life supernaturally extended Men thought the acme of happiness would be to live here forever They would be like the deities, whom they called 'immortals'[81] In *The Dying God*[82] Frazer says that savages believe themselves naturally immortal Certainly the myths and legends of many lands postulate immortality as natural to man and numerous stories are fabricated to explain the origin of death[83]

We have seen how the Greeks of the Heroic Age yearned for deathlessness Both they and their descendants thought it possible to secure immortality by magical means or through the kindness of the gods

Partaking of the food and drink of the gods would enable one to escape death[84] The Hours and Gaea, wishing to make

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[80] H G Evelyn-White's translation in the Loeb Classical Library, I 361

[81] There were a few other beings that were immortal, e g, Calypso (*Odyss*, 5 209), Charybdis (*Odyss*, 12 118), the Fates (Tzetzes, *ad Lyc Alex*, 406), Silenus (Theopompus, in Mueller, *Frag Hist Graec*, I 290)

[82] P 1

[83] See "Myths of the Origin of Death," in Frazer, *The Belief in Immortality*, I 59–86. Compare Plato, *Politicus*, 273 e

[84] Aristotle, *Metaphys*, 2 4 12, attributes this idea to Hesiod and his contemporaries The statement is made in negative fashion, to the effect that those who have not tasted of nectar and ambrosia are mortal Pindar, *Olymp*, 1. 62, seems to believe that a man would live as long as the gods if he had the divine diet In the Homeric poems it is not explicitly stated that ambrosia and nectar make one immortal See Seymour, *Life in the Homeric Age*, p. 402 Compare also *Homeric Hymn to Delian Apollo*, 124–129. In *Iliad*, 19 347–348, Athena brings nectar and ambrosia to Achilles in order to enable him to allay the pangs of hunger

Aristaeus immortal, put nectar and ambrosia on his lips,[85] Cyprian Aphrodite dropped ambrosia upon the breast of Berenice[86] Zeus had Hera nurse the youthful Heracles[87]

Tantalus was denied food and drink by the gods because he wished to make his friends immortal by sharing with them the nectar and ambrosia of the gods[88]

Athena begged from Zeus a medicine with which she intended to make Tydeus immortal[89] Glaucus, the fisherman, acquired immortality by eating the herb or grass which he saw restore fish[90] (or a dying hare[91]) to life[92]

A number of mythical beings were supposed to be able to confer eternal life We have seen that Calypso tried to beguile Ulysses with a promise of this boon Moera made Hippon immortal;[93] Glaucopis, Diomedes[94]

All-powerful Zeus seems to have restricted his efforts in this direction to everlasting existence in the hereafter. He made Amphiaraus immortal, but in Hades[95] He promised immortality or rather deification to one of the sons of Ares.[96]

The accounts about the perpetual sleep of Endymion do not agree. Apollodorus says that Selene fell in love with his wonderful beauty and that Zeus granted him permission to choose what he would He expressed a wish to sleep forever and to remain deathless and always youthful.[97] Others say that Zeus in anger doomed him to sleep eternally [98] 'Sleep of Endymion' became a commonplace in both Greek and Latin literature [99] (See Fig 1 )

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[85] Pindar, *Pyth* , 9 68 (110)

[86] Theocr , 15. 106–108 Cf 17 46–47, where it appears that Berenice escaped Hades

[87] *Geopon* , 11 19 See likewise Lyc , *Alex* , 1327–1328, with Tzetzes, *ad loc* , Paus , 9 25 2, Diod., 4 9. 6 According to Diodorus, 4 9 5, Heracles was to secure immortality after performing the twelve labors enjoined by Eurystheus

[88] Pindar, *Olymp* , 1 60–64, Philostr , *Vita Apoll* , 3 25, Tzetzes, *Chil* , 5. 463–466

[89] Apollod , *Bibl* , 3 6 8

[90] Ovid, *Met* , 13 924–952, Servius, on Verg , *Georg* , 1 437, Ausonius, *Mosella*, 276 ff , Paus , 9 22 7, Athen , 7 296 f, schol on Apoll Rhod , *Argonaut* , 1 1310, Palaephatus, 27 (28), Tzetzes, *ad Lyc Alex* , 754.

[91] Nicander, cited by Athenaeus, 7 297 a

[92] For references to similar tales in comparative folklore see Frazer, *Pausanias*, V 95–96, *idem*, *Folk-Lore in the Old Testament*, I. 50 ff.

[93] Clemens Alex , *Protr* , 4 55 (ed Stählin, I· 43)

[94] Schol Pind , *Nem* , 10 12

[95] Apollod., *Bibl* , 3 6 8 See Frazer's note *ad loc.*

[96] Ovid, *Fasti*, 2 487

In the *Homeric Hymn to Aphrodite* [100] we are told how Dawn requested of Zeus that her beloved Tithonus might live forever, but unwittingly forgot to ask for eternal youth The petition was granted, but in the course of years Tithonus found himself suffering so much from the infirmities of age that he prayed for death, although he could not die [101] In pity the goddess shut him up in a chamber and left him there to babble forever Another version [102] says that Tithonus asked Dawn herself for immortality, but carelessly neglected to ask for agelessness When he was weighed down with age he besought the goddess to transform him, since he could not die According she changed him into a cicada, 'the most musical of winged things,' in order that she might never cease to hear and enjoy the beauty of his voice [103]

There are traditions to the effect that Thetis tested the immortality of her children by throwing them into a cauldron of (boiling) water or into fire Six of her children perished in this way, but Peleus saved the seventh, Achilles [104] The more common tale is that she tried to make him immortal by burning out by night the mortal element inherited from his father and by anointing him by day with ambrosia [105]

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[97] *Bibl* , 1. 7. 5 Zenobius, *Cent* , 3 76, is obviously indebted to this passage

[98] Schol ad Theocr , 3 49, Apoll Rhod , *Argonaut* , p 487, ed Merkel-Keil

[99] Plato, *Phaedo*, 72 C, Macarius, *Cent* , 3 89, Diogenianus, *Cent* , 4 40, Cic , *De Fin* , 5 55, *idem*, Tusc *Disp* , 1 92

[100] Lines 220–238

[101] Cf Hor , *Carm* , 2 16 30 *Longa Tithonum minuit senectus*

[102] Schol , *Il* , 11 5 See too pseudo-Plutarch, *Proverbia Alexandrinorum*, No LXVIII (Dübner's edition of Plutarch, V 169)

[103] Photius, 368 a 16 (ed Bekker), says that locusts were men in days long past They had, however, gone through the intermediate stage of 'birdhood'

[104] Schol. Apoll Rhod , *Argonaut* , p 507, ed Merkel-Keil

[105] Apoll Rhod , *Argonaut* , 4 869–872, Apollod , *Bibl* , 3 13 6; Schol , *Il* , 16 37 (ed Dindorf, iv· 109) Cf Tzetzes, *ad Lyc Alex* , 178

Fig. 1. Endymion Doomed to Eternal Sl

To make Triptolemus deathless Demeter stroked him three times with her hand, spake three incantations, and put his body on a hearth with embers still alive [106] When Demophon, the son of Metanira and Celeus, was given to Demeter to nurse, the goddess set him upon the fire in order to strip off his mortal flesh [107] In somewhat similar fashion Isis tried to confer immortality upon the infant son of the king of Byblos by placing him on a fire [108] Parallels to such stories have been collected by Frazer [109]

Through nobility and beneficial acts to mankind it was possible to secure a special kind of immortality, i e. apotheosis or deification [110] Endymion was made a god because of his great justice; [111] Argive Diomedes, because of his valor, [112] Heracles and Dionysus, because of their virtues, [113] some of the Egyptian kings, because of their benefactions [114] Diodorus [115] makes the generalization that gods were originally men who performed great services to mankind and Heraclitus defines gods as 'immortal men' [116] Empedocles [117] went so far as to say "An immortal god and no longer a man I wander among you" Deification is, however, a little aside from our theme

### *The Life-Token*

There is a "widespread class of tales concerned with the 'external soul,' or the belief that a person's life is bound up with an object outside of his own body" [118] The loss or destruction of this life-token involves the death of the person with whom it is in vital relation. We might almost describe this situation as 'conditional' immortality.

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[106] Ovid, *Fasti*, 4 551-554 Her efforts came to naught, however, because she was interrupted

[107] Apollod , *Bibl* , 1 5 1, *Homeric Hymn to Demeter*, 236-240

[108] Plut , *Mor* , 357 c Her failure, like that of Demeter with Triptolemus, was explained as due to an interruption in the ceremony

[109] In his edition of Apollodorus, II 311-317 When Scylla was killed by Heracles her father welded her together again by fire — Tzetzes, *ad Lyc Alex* , 49. Cf. Dionys in *Schol Hom Odyss* , 12 85

[110] "Ob merita virtutis aut muneris deos habitos Euhemerus exsequitur. . . ." — Min. Felix, 21 1 See also sections 2-7 Contrast Plut , *Mor* , 415 B

[111] Apollonii *Argonautica*, p 487, ed. Merkel-Keil

[112] Schol. Pind , *Nem* , 10 2

[113] Plut , *Pelop* , 16 5

[114] Diod., 1 13 1

[115] *Loc cit*

[116] Lucian, *Vit Auct* , 14

[117] Diogenes Laertius, 8 (62), c 6

[118] Frazer, *Apollodorus*, I 65, note 5

Several instances of such things are to be found in classical literature. Poseidon made Pterelaus immortal by implanting a golden hair on his head. Amphitryon ravaged the islands of the Taphians which he governed, but could not take Taphos itself until the daughter of Pterelaus fell in love with her country's enemy and pulled the golden hair from her father's head, whereupon he died and all the islands were subjugated.[119]

A remarkably similar tale is told of Nisus, king of Megara, who had a purple or golden hair upon his head. When Minos was besieging Megara, the king's daughter fell in love with him, plucked the hair from her father's head and caused his death.[120]

It is said that when Meleager was seven days old the Fates came and declared that he would die when the brand burning upon the hearth was consumed. On hearing this Althaea, his mother, snatched up the brand and deposited it in a chest. In a quarrel after the celebrated boar hunt Meleager slew two of his mother's brothers, whereupon she kindled the brand and caused her son to expire.[121] Euripides had a play upon this theme, but he made the life of Meleager dependent upon an olive leaf to which his mother had given birth along with her son.[122]

There is a fairly close Roman parallel to this story. Silvia, the young wife of Septimius Marcellus, had a son by Mars. The god gave her a spear with which it was said that the fate of the child should be bound up Like Meleager, years later he slew his mother's brothers and she burned the spear and brought about his death [123]

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[119] Apollod., *Bibl.*, 2. 4. 5, 7. Cf. Tzetzes, *ad Lyc. Alex.*, 932.

[120] Apollod., *Bibl.*, 3. 15. 8, Aesch., *Choeph.*, 617, Verg., *Ciris*, 116 ff., Ovid, *Met.*, 8. 8 ff. For many references to the story of Nisus, see Frazer, *Apollodorus*, II. 117.

"According to J. Tzetzes (*Schol. on Lycophron*, 650) not the life but the strength of Nisus was in his golden hair, when it was pulled out, he became weak and was slain by Minos. According to Hyginus (*Fab.* 198) Nisus was destined to reign only so long as he kept the purple lock on his head." — Frazer, *Balder the Beautiful*, II. 103, note 3.

For parallels to the stories of Pterelaus and Nisus and references to still others, see Cook, *Zeus*, p. 343, n. 4.

[121] Apollod., *Bibl.*, 1. 8. 2–3. For many references see Frazer, *ad loc.*

[122] See J. Malalas, *Chronographia*, pp. 165–166, ed. Dindorf, J. Tzetzes, *Schol. on Lyc. Alex.*, 492–493.

In the year 927 A.D. the Byzantine emperor Romanus I

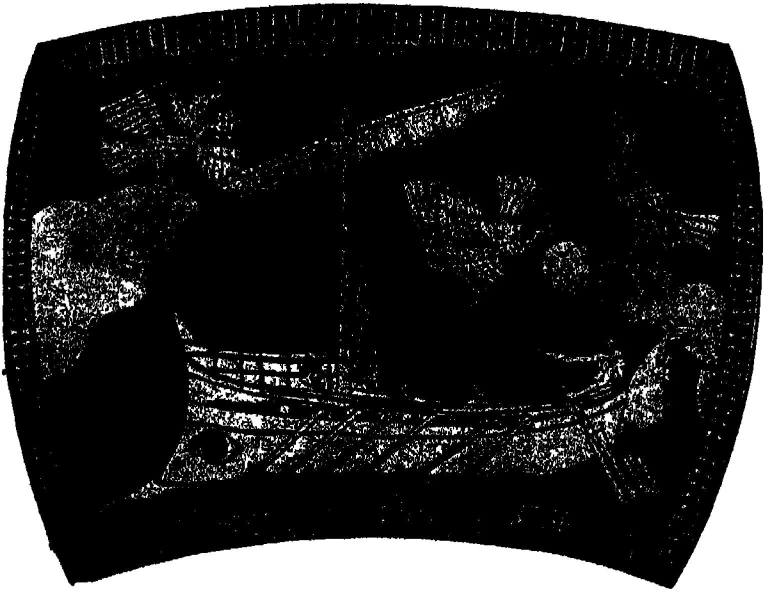

FIG 2 Ulysses Passing by the Shores of the Sirens
(from Furtwangler, *Griechische Vasenmalerei*, Tafel 124)

(Lecapenus), on learning that a certain statue had a magical connection with the life of the Bulgarian Symeon, had the head cut off At the same hour Symeon was taken sick and quickly died.[124–125]

Stories illustrative of the life-token suggest others in which the continuance of life is represented as dependent upon the maintenance of conditions of a somewhat different character. Alcyoneus, one of the Giants, was immortal so long as he remained in his native land On the advice of Athena, Heracles dragged him beyond the borders and slew him [126] Neither could Antaeus be conquered while he remained in contact with earth [127]

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[123] Plut , *Parallels*, 26

[124] Zonaras, Vol III, p 473, lines 7–15 (ed Bonn)

[125] For general references to the subject of the life-token see E S Hartland, *The Legend of Perseus*, II 1–54, "The Separable Soul," in Macculloch, *The Childhood of Fiction*, pp 118–140, Frazer, "The External Soul in Folk-Tales," *Balder the Beautiful*, II 95–152

The Sirens, whose enchanting songs caused mariners to hurl themselves into the sea, were doomed to die whenever a sailor heard their voices and yet passed by in safety [128] By filling the ears of his men with wax and having himself bound to the mast of his ship, Ulysses succeeded in doing this, whereupon the Sirens cast themselves from the rocks into the waters [129] (See Fig. 2 )

Talos who guarded Crete had only one vein in his body. It ran from his neck to his ankles (both ankles!) and was closed at the end by a bronze nail It was fated that he should die when the vein was broken [130] According to Apollonius Rhodius [131] the vein and the light membrane which he says was beneath it were both significant of life and death [132] Under pretense of making him immortal Medea took the nail out of his vein and thus caused him to bleed to death [133]

In the case of several cities, their 'salvation,' which is practically only another way of saying their 'continued existence,' was regarded as dependent on the safety of the statues of deities The most famous instance is that of the Palladium of Troy.

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[126] Apollod , *Bibl* , 1. 6 1 Compare Tzetzes, *schol on Lycophron*, 63

[127] Apollod , *Bibl* , 2 5 11 See too Ovid, *Ibis*, 394, Juvenal, 3. 89, Lucan, *Phars* , 4 598–600

[128] *Odyss* , 12 38–54, 165–200, Hyg , *Fab* , 141 Cf 125 *Harum fatum fuit tamdiu vivere quamdiu earum cantum mortalis audiens nemo praetervectus esset*

[129] Bode, *Scriptores Rerum Mythicarum Latini Tres*, 1 186, 2 101 Cf Strabo, 6 1, p 252 c, Apollod , fr Sabb , 7 18 The destruction of the Sirens is sometimes connected with the story of Orpheus and the Argonauts See Apollod , *Bibl* , 1 9 25

[130] Schol on Apoll Rhod , *Argonaut* , 4. 1638 The story is told also in Apollod , *Bibl* , 1 9 26

[131] *Argonaut* , 4 1648. On the subject of Talos see Cook, *Zeus*, I 719–730

[132] In view of these details perhaps this story too should be regarded as illustrating the life-token Berthold (see p 45 of article cited on p 54), seems to class the story of Talos with those of Nisus and Pterelaus

[133] Apollod , *Bibl.*, 1 9 26

### *Invulnerability*

There were heroes whose life could not be brought to an end through outside agencies except in one vital spot Such was Achilles In an effort to make him invulnerable — some say immortal — his mother Thetis dipped him in the Styx, but the water failed to touch the place where she held him by the heel.[184]

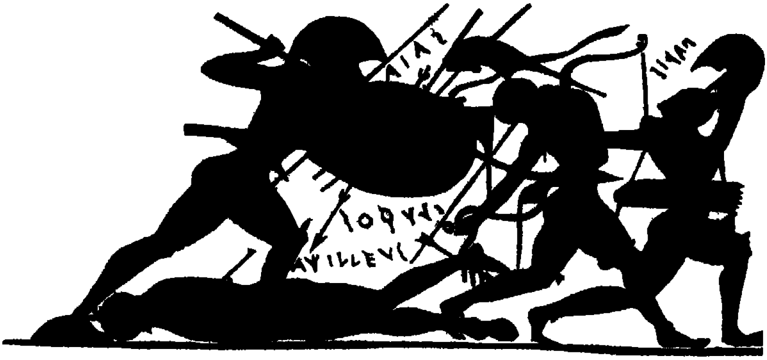

FIG 3 The Fight over the Corpse of Achilles, Who is Mortally Wounded in His One Vulnerable Spot, the Heel
(from *Monumenti Inediti, Pubblicati dall' Instituto di Corrispondenza Archeologica* I, Plate LI)

It was here that Paris, or Apollo in the guise of Paris,[185] inflicted the fatal wound with an arrow (See Fig 3 )

Closely akin to this story is that of Ajax In his infancy Heracles wrapped a lion's skin about him and prayed that the child might be invulnerable where the skin touched him The quiver of Heracles, however, prevented the skin from touching his side, and so left a vulnerable spot [186] According to another story Heracles was vanquished only after he laid aside a magical *lapis Gagatromanes* [137] In similar manner Milo of Croton never suffered defeat as long as he carried a *lapis alectorius* [138]

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[184] Stat , *Achill.*, 1 269–271, Serv , *ad Verg Aen* , 6 57 Fulgentius, *Mythol* , 3. 7, says his mother wished to make him capable of facing every kind of hardship.

[185] Hyg , *Fab* , 107 Cf. Quintus Smyrnaeus, 3 62

[186] Lycophron, *Alex* , 455–456, Tzetzes, *ad loc* , Plato, *Symp* , 219 E Cf. Pindar, *Isth.*, 6 44–49 (63–71).

"Caeneus was formerly a woman, but after that Poseidon had intercourse with her, she asked to become an invulnerable man, wherefore in the battle with the centaurs he thought scorn of wounds and killed many of the centaurs, but the rest of them surrounded him and by striking him with fir-trees buried him in the earth" [139]

Numerous other instances of invulnerability are given in a long article by O Berthold, *Die Unverwundbarkeit in Sage und Aberglauben der Griechen* [140]

### *Immortality of Animals*

Several horses were endowed with eternal life The most famous was Pegasus Others were Balius and Xanthus, which Poseidon gave to Peleus as a wedding-present [141] In the Iliad [142] they are described as "ageless and undying"

## REJUVENATION

Youth is ever idealized With reluctant resignation Theognis [143] says that it is not granted to mortals by the gods to have youth twice In the Iliad,[144] however, it is implied that deities can cast off a man's old age and make him young again Athena restores the youthful appearance of Ulysses merely with a touch of her wand [145] Hebe, the goddess of youth, brought back Iolaus to the vigor and the appearance of young manhood [145a]

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[137] Damigeron, *De Lapidibus*, XLI (*Orphei Lithica*, ed Abel, p 193)

[138] Damigeron, *op cit*, XIX (*Orphei Lithica*, ed. Abel, p 178).

[139] Frazer's translation of Apollod, *Epit*, 1 22 For many other references, see Frazer, *ad loc*

[140] This is the first article in *Religionsgeschichtliche Versuche und Vorarbeiten*, Vol 11 It contains seventy-three pages For an additional interesting magical method see *Catalogus Codicum Astrologorum Graecorum*, VI 61, lines 5–9

[141] Apoll, *Bibl*, 3 13 5 Cf *Iliad*, 16. 154

[142] *Iliad*, 17 443–444.

[143] Line 1003

[144] 9 445–446.

[145] *Odyss*, 16 172–174.

[145a] Ovid, *Met*, 9 394–400.

An ancient Lesbian folk-tale records how Aphrodite gave to Phaon, her ferryman, a salve which imparted beauty and youth [146] Anise seed, too, was supposed to impart a more youthful look to the features.[147]

The most famous restorer of youth was of course Medea At the request of Jason, who besought her to take away some of his own years and add them to his father's, she undertook to make the old man young again After long and elaborate preparations [148] she purified the old man thrice by fire, thrice by water, thrice by sulphur

" Meanwhile the strong potion in the bronze pot is boiling, leaping and frothing white with the swelling foam In this pot she boils roots cut in a Thessalian vale, together with seeds, flowers, and strong juices She adds to these ingredients pebbles sought for in the farthest Orient and sands which the ebbing tide of Ocean laves She adds hoar frost gathered under the full moon, the wings of the uncanny screech-owl with the flesh as well, and the entrails of a werewolf which has the power of changing its wild-beast features into a man's There also in the pot is the scaly skin of a slender Cinyphian water-snake, the liver of a long-lived stag, to which she adds also the head of a crow nine centuries old When with these and a thousand other nameless things the barbarian woman had prepared her more than mortal plan, she stirred it all up with the branch of the fruitful olive long since dry and well mixed the top and bottom together And lo, the old dry stick, when moved about in the hot broth, grew green at first, in a short time put forth leaves, and then suddenly was loaded with teeming olives And wherever the froth bubbled over from the hollow pot, and the hot drops fell upon the ground, the earth grew green and flowers and soft grass sprang up . When she saw this, Medea unsheathed her knife and cut the old man's throat, then letting the old blood all run out, she filled his veins with her brew.

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[146] Ael., *Var Hist*, 12 18, Serv, *ad Verg Aen*, 3 279, Palaephat, 49, Lucian, *Dial Mort*, 9 2 See also Roscher, s v *Phaon*

[147] Plin, *Nat Hist.*, 20 186 Cf Dyer, *The Folk-Lore of Plants*, p 290 "One of the special virtues of rosemary was its ability to make old folks young again"

[148] Ovid, *Met*, 7 159-260

When Aeson had drunk this in part through his lips and part through the wound, his beard and hair lost their hoary grey and quickly became black again, his leanness vanished, away went the pallor and the look of neglect, the deep wrinkles were filled out with new flesh, his limbs had the strength of youth. Aeson was filled with wonder, and remembered that this was he forty years ago." [149]

FIG. 4 The Rejuvenation of the Ram by Medea

Pelias is the seated figure to the left. In front of him stands Medea, while the daughters of Pelias are at the extreme right. (Reproduced from Baumeister's *Denkmaler des klassischen Altertums*, II 1201)

Medea then proceeded to the palace of Pelias, prepared to wreak vengeance upon him for his wrongs to his nephew. She proved her ability to the daughters of Pelias by changing her own looks from those of an old woman to a maid,[150] and also by boiling a decrepit ram in a cauldron of herbs[151] and making it young again[152] The daughters killed their father, but the cauldron was now filled with powerless herbs and failed to work.[153] (See Fig 4.)

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[149] Ovid, *Met.*, 7. 262–293 (F. J. Miller's trans.).

[150] Diod., 4. 51. 5

[151] Ovid, *Met.*, 7. 309–321; Diod., 4. 52. 1–2.

Medea is credited with restoring other people to youth by decoction, among them her husband Jason and the nurses of Dionysus, together with their husbands[154] Youth was restored to the daughters of Oceanus, presumably by boiling[155]

The virtues of boiling water were quite generally recognized Tantalus killed his son Pelops, cooked him in a kettle, and served him at a banquet of the gods.[156] In pity the deities restored him to life by boiling him in a cauldron[157] When he came out again he was fairer than ever to look upon[158] Demeter[159] (or, according to others, Themis[160]) had unwittingly partaken of the repast and hence ivory was used to replace the flesh of the shoulder that she had eaten The substitute was afterwards exhibited at Elis,[161] but was not seen by Pausanias.[162]

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[152] For other references to these activities of Medea see Diodorus, 4. 51 (entire), Paus , 8 11 2, Zenobius, *Cent* , 4 92, Plaut , *Pseud* , 868–871, Cic , *De Senec* , 23 83, Hyg., *Fab* , 24, Apollod , *Bibl* , 1. 9. 27, Lactantius Placidus, *Narrationes Fabularum*, 8 2–4

[153] Ovid, *Met* , 7 322–349 Cf Diod , 4 52 2–5

[154] Scholium on Aristoph , *Eq* , 1321, and the Greek Argument to the Medea of Euripides See E Maas, "Aschylus und Aristophanes," *Neue Jahrbücher für das klassische Alterthum*, 31 627–636

Frazer, *Apollodorus*, II 359–362, cites many parallels to the story of Medea and Pelias See also his edition of Pausanias, on 8 11 2

[155] Hyg , *Fab* , 182

[156] See Pindar, *Olymp* , 1 24 (37) ff , together with the scholia on 40, Lucian, *De Salt* , 54, Tzetzes, *ad Lyc Alex* , 152, Serv , *ad Verg Aen* , 6 603 and on *Georg* , 3 7, Hyg , *Fab* , 83, *Scriptores Rerum Mythicarum Latini*, ed G H Bode, I 109, 186 (Second Vatican Mythographer, 102, Third Vatican Mythographer, vi 21)

[157] Bacchylides (ap Schol. Pind , *Olymp* , 1 40a, Vol I, p 30, ed Drachmann) says, however, that it was Rhea was revived him by passing him through the cauldron. In Pindar's revised version he is taken out of the cauldron by Clotho. See *Olymp* , 1 40 (26) and scholium *ad loc.*

[158] Apollod , 2 3.

[159] Serv., *ad Verg Georg* , 3 7, *idem*, *ad Aen* , 6 603.

[160] Scholium on Pindar as cited in note 157

[161] Pliny, *Nat Hist.*, 28. 34 Cf. Ovid, *Met* , 6. 404–405.

[162] See 5. 13. 6.

Dionysus,[163] or, to use his mystic surname, Zagreus,[164] was cut up and thrown into a cauldron by the Titans, but Demeter restored him to life  Most accounts speak simply of his restoration, but two authors do say that he became young again [165]

In the Equites [166] of Aristophanes the sausage-seller exercises his art as cook and then says "By boiling Demos I have made him beautiful for you instead of ugly"  It is clear from the Argument of the play that this is an instance of rejuvenation

### *Rejuvenation and the Drama*

"This turning of an old man into a youth is by no means confined to the *Knights*  It was the principal theme of the lost play [of Aristophanes] called *Old Age*  In this comedy the Chorus appears to have consisted of old men who threw off their age, as the serpent casts his slough,[167] and behaved themselves with youthful licence and indecorum . . Two of the fragments may possibly indicate that the process of rejuvenation was performed by a Cook [168]  We should then have a comic parallel to Medea's boiling of the whole Chorus in Aeschylus' *Nurses of Dionysus*  The same motive was used again in the *Amphiaraus*, where a superstitious old man goes on pilgrimage to Oropus, to recover his youth by Incubation in the temple . . " [169–170]

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[163] Diod , 3 62 6–7  Cf Cornutus, *Theologiae Graecae Compendium*, c 30 *ad finem*, Mythog Vat , III 12, p 246, ed Bode, Arnob , *Adv Nat* , 5 19  See also Farnell, *Cults of the Greek States*, V 183–192  On restoration of Semele, see pages 193–194

[164] Macrobius, *Somn Scip* , 1 12 (= Abel, *Orph* , Frag , 206)

[165] Diod , 3 62 6; Proclus, *Hymnus in Minervam*, 5 11 ff  (= Abel, No 206)

[166] Line 1321

[167] Ar , Frag. 178 Dind

[168] "Frag  184 Dind = Pollux x. 104  *Αριστοφάνους γοῦν ἐν Ἱππεῦσιν ὁ μάγειρος λέγει 'μαχαιρίδων τε πλήγας' ὥσπερ καὶ ἐν τῷ Γήρᾳ ὁ αὐτὸς ποιητὴς εἴρηκε 'κοπίδι τῶν μαγειρικῶν'*  When this reference to the cook's knife is taken in conjunction with Frag  185*a* as restored by Fritzsch  *ἐγῷδ' ἀπολοπίζειν γε καὶ τἀπ' ἀνθράκων*, it seems certain that a cook was a character in the play, and possible that he rejuvenated the old men by peeling off their skins, as if they were snakes" — Cornford, *The Origin of Attic Comedy*, p 91, n 3

[169] "See Kaibel, s v  'Aristophanes' in Pauly-Wiss. ii 979, citing frag 102 Dind = Erotian, 93, 8 Kl" — Part of note 5 in Cornford, *op cit* , p 91

[170] Cornford, *op cit* , pp 90–91

"But, besides these cases, it is the usual thing for Aristophanes' elderly heroes in the course of the play to throw off the slough of sour and morose old age, and emerge at the end carrying their youthful behaviour to the point of scandal "[171]

" it is certainly a curious feature which distinguishes Aristophanes' plays from all other forms of Comedy, that they present a whole series of heroes who are old men and behave as such at the beginning, while at the end they are more or less transfigured into youthful bridegrooms When Trygaeus returns from heaven, the Chorus sing that 'the old man' seems to have found happiness and prosperity 'What will you say, then,' says Trygaeus, 'when you see me in my glory as a bridegroom?' 'All will envy you, old man, when you have become a youth once more and are anointed with myrrh '[172] The case of Trygaeus is not exceptional, but typical Dikaiopolis, Demos, Strepsiades, Philocleon, Pisthetairus, Blepyrus, Plutus — all these undergo, in some sense, a similar rejuvenation This is not an obvious course for the action of a comedy to take, and that not once or twice, but so normally that we find it in eight out of the eleven extant plays, while of the remainder one (the *Frogs*) leads up to the resurrection of the elder poet, another (the *Lysistrata*) has no male hero at all."[173]

## *Water of Life*

The cauldron that Medea used has at times been associated with the Fountain of Youth, but wrongly so[174] The classical writers had no genuine native tradition of such a fountain, but some of the later writers knew of it among other peoples The rejuvenating bath for the eagle was familiar, however, to Jerome,[175] who says that it regained its youth by immersing itself three times in a fountain Donatus tries to explain the *aquilae senectus* of Terence[176] in this fashion, but St Augustine, in commenting on Psalm ciii 8, "Thy youth is renewed like the eagle's," makes no mention of the belief[177] Greeks and Romans knew of traditions, most of them foreign, about the power of certain waters to impart youthful vitality and vigor.

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[171] Cornford, *op cit*, 91

[172] Trees struck by lightning revived when anointed with myrrh — *Geoponica*, 10 79

[173] Cornford, *op cit*, pp 92–93 See also page 93, note 2 "The rejuvenation motive occurs in the *Bacchae* in the persons of Cadmus and Teiresias 184 *ποῖ δεῖ χορεύειν, ποῖ καθιστάναι πόδα,* | *καὶ κρᾶτα σεῖσαι πολιόν, ἐξηγοῦ σύ μοι* | *γέρων γέροντι, Τειρεσία ἐπιλελήσμεθ' ἡδέως* | *γέροντες ὄντες Τειρ ταὔτ' ἐμοὶ πάσχεις ἄρα* | *κἀγὼ γὰρ ἡβῶ κἀπιχειρήσω χοροῖς* Van Leeuwen cites these lines to illustrate the song of the Mystics in the *Frogs* 345 *γόνυ πάλλεται γερόντων·* | *ἀποσείονται δὲ λύπας* | *χρονίους δ ἐτῶν παλαιῶν ἐνιαυτούς* Cf the Chorus of Old Men in the *Lysistrata* (Parabasis) 669 *νῦν δεῖ νῦν ἀνηβῆσαι πάλιν κἀναπτερῶσαι* | *πᾶν τὸ σῶμα κἀποσείσασθαι τὸ γῆρας τόδε* "

[174] See E W. Hopkins, "The Fountain of Youth," *J. A O S*, 26 1-67, especially pages 38-43 See also E Rohde, *Psyche*,[4] II 390, Tylor, *Re-*

The Ethiopians lived 120 years or more When Cambyses sent messengers to find out the secret, they were taken to a spring the waters of which were so light that neither wood nor substances more buoyant than wood could float upon it After they had bathed, their bodies shone as if they had been anointed with oil and they gave off an odor like the scent of violets[178] The long life of the Seres (300 years) was attributed by some to their diet, "for they say that this entire nation drinks nothing but water"[179]

Beyond the region of the Hyperboreans and Meropes there was the land of Anostos, "the undiscovered country from whose bourn no traveler returns" Around it flowed broad rivers, one of Pleasure, the other of Sadness, beside whose banks grew large fruit-trees. Those who tasted of the fruit of the trees beside the

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*searches into the Early History of Mankind* (1865), pp 352–355, Hastings, *Encyclopaedia of Religion and Ethics*, s v *Fountain of Youth*

[175] *Ep ad Praesidium*, 18 4 (Migne, *Patrol Lat*, 30 187) The same story is told by Eustathius (Migne, *Patrol Graec*, 18 732) and by Epiphanius (?), *Physiol*, 6 (Migne, *Patrol Graec*, 43 524)

[176] *Heaut. Tim*, 521 Cf Auson, *Prof*, 4. 22

[177] Pliny, *Nat. Hist.*, 10 7, says that the life of a certain species of eagle is spent around lakes. This may or may not be significant Eugraphius, in commenting on the passage in Terence already referred to, mentions a popular belief that in old age the eagle lives by drinking It is explained that it cannot eat because the end of its beak becomes too much curved. Pliny, *Nat Hist.*, 10 15, and others say the same thing It is barely possible that this explanation may have been invented after a belief in life-giving waters had dropped from memory.

[178] Herod, 3 23. Cf. Pomp. Mela, 3 9.

[179] Lucian (?), *Longaevi*, 5.

river of Sadness died amid tears and sorrow, while those who ate of the other fruit cast off their old age, and returned to the height of their strength, then to youth, boyhood and infancy, and finally died[180]

St Paul was not the only one who could turn pagan beliefs to good account. Julius Firmicus Maternus[181] cleverly says in addressing Egyptians· "In vain do you think this water which you cherish has some virtue. there is another water with which men are renewed and reborn"

Many such stories among other peoples have been collected,[182] but no people ever searched for life-giving waters with more implicit belief or with greater pertinacity than the Spaniards in the New World[183] One scout "actually saw and conversed with men who had drunk at the Fountain of Youth, and had comfortably passed their first quarter of a thousand years."[184]

## *Renewal of Youth by Animals*

The supposed ability to renew youth was both more general and easier for the lower orders than for man It is an illuminating fact that in both Greek and Latin the words for 'old age' (*γῆρας*, senectus, senecta) are employed also to designate the cast-off skin of an animal[185] As Frazer points out,[186] such uses indicate a belief in the renewal of youth by sloughing the skin As might be expected this idea is hoary with age, for Homer uses the same type of expression for casting off old age[187] as later writers do to describe the casting off of the skin or other integuments by animals

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[180] Ap Ael., *Var Hist*, 3 18 On the retracing of life back to infancy and even to disappearance or non-existence, see Plato, *Politicus*, 270 d–e

[181] *De Errore Profanarum Religionum*, c 2

[182] See "The Water of Life," pp 52–79, of J A Macculloch, *The Childhood of Fiction*

[183] They heard about these waters from the Indians of course "It was said and believed by the Indians of Cuba and Española that by bathing in the river [a certain river in Florida] or the fountain [Bimini], old men became youths" — H E. Bolton (quoting Herrera), *The Spanish Borderlands*, p 36

[184] H R. Bolton, *op cit*, p 36

[185] *Λεβηρίδος ὑμενώδους ἀποσύρματος, ὅπερ ἐστὶ τὸ τῶν ὄφεων λεγόμενον γῆρας, ὡς καὶ Ἀριστοφάνης ἐν Ἀμφιαράῳ* (Erotian, 93, 8 Kl = Frag 102 Dind), *ἔστι δὲ λεβηρὶς τὸ τοῦ ὄφεως γῆρας διὰ τὸ λέπος εἶναι* (Hesychius, s v *Γυμνότερος λεβηρίδος*), *γῆρας ἐστι τοῦτο τὸ ἔσχατον δέρμα καὶ τὸ περὶ τὰς γενέσεις κέλυφος* (Arist, *De Anim. Hist*, 8 17, 600 b 17. (The passage from Aristotle is bracketed in the Teubner edition.) See too Pliny, *Nat Hist*, 8 111, 9 95, 20 254, 28. 174, 30 57, 69, 81

[186] *Folk-Lore in the Old Testament*, I. 50, note 1

Aristotle[188] tells us that almost all soft-skinned animals that have scales 'cast their old age' He mentions the gecko, lizard, the viper and serpents in general, among the marine creatures, the carabi and astaci, among insects, the silphe, empides, the coleoptera[189] and cicadas[190]

Pliny the Elder, relying chiefly if not wholly upon Greek sources, names several members of the animal kingdom which were supposed to renew their youth with a change of integument, among them crayfish, crabs[191] and newts[192] Another author[193] informs us that locusts slough their old age

Birds molt, but the process is not so sudden or so obvious as the changes in the case of snakes and some insects Hieronymus,[194] however, says that old eagles regain the strength of youth with a change of feathers. A fresh skin, shell or plumage is not a requisite for the belief in the renewal of life, since dormice were supposed to be young again after hibernating throughout the winter[195]

The most picturesque and circumstantial account of the renewal of youth by an animal is as follows "When the snake has grown old, it loses its sight If it wishes to become young again, it fasts for forty days, so that its skin may become loosened, and thus it seeks a narrow opening, so that while it is trying to squeeze through, it gets rid of the skin of old age"[196]

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[187] *Iliad*, 9 445–446 γῆρας ἀποξύειν Aristotle uses ἐκδύειν

[188] *De Anim Nat*, 8 17 See also Theophrastus in Athenaeus, 3 65 end

[189] In Egypt the scarabaeus was a symbol both of the renewal of life and of the resurrection — Elworthy, *Horns of Honour*, p 219

[190] Cf Tzetzes, *ad Lyc Alex*, 18

[191] 9 95.

[192] 8 111 Cf. Ael, *De Nat Anim*, 3 17

[193] Tzetzes, *ad Lyc Alex*, 18.

[194] *In Isaiam*, c 40 *ad finem* (Migne, *Patrol Lat*, 24 412)

[195] Pliny, *Nat. Hist*, 8 224

[196] Hieronymus, *Ep ad Praesid*, 18 4 (= Migne, *Patrol Lat.*, 30 187) See too *Patrol Graec*, 18· 748, 43 528

The Phoenician Sanchuniathon[197] likewise attributed the "extremely long life" of the snake to its casting its skin and so renewing its youth.[198] In conformity with this belief is the legend that the snake did not die a natural death, but came to its end only as a result of violence[199] With such views so prevalent and so widespread it is not strange that the serpent became a symbol of old age and, according to the same source,[200] of Asclepius, who *renewed the bodies of men through the healing art*[201]

To the generalization that "Many savages believe that, in virtue of periodically casting their skins, certain animals and in particular serpents renew their youth and never die," [202] Frazer adds that "not a few peoples appear to believe that the happy privilege of immortality, obtainable by the simple process of periodically shedding the skin, was once within reach of our species, but that through an unhappy chance it was transferred to certain of the lower creatures, such as serpents, crabs,[203] lizards, and beetles" [204]

Frazer conjectures that in the original story of the Garden of Eden there were two trees, the Tree of Death and the Tree of Life, and that the serpent by its guile persuaded the first pair to eat, not of the Tree of Life, which would have enabled them to live forever, but of the Tree of Death, and that it itself acquired the immortality which should have been man's.[205]

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[197] Euseb , *Praep Evang* , 1 10

[198] For still other references to the casting of skins by snakes and the renewal of youth, see Aristoph , *Plut* , 733, Ael , *De Nat Anim* , 9 16, Nicander, *Ther* , 355–356, Dio, 61 2 4, Nonn Dionys , 41 180–182, Horapollo, *Hieroglyphica*, 1 2, Tzetzes, *ad Lyc Alex* , 18, Verg , *Aen* , 2 473, Verg , *Georg* , 3 437, Serv ad Verg., *ll cc* , Ovid, *Met.*, 7 237.

[199] Eusebius, *loc cit* Cf Hieronymus, *loc cit*

[200] Other reasons have been advanced, however, for the association of the snake with Asclepius

[201] *Analecta Eratosthenica*, p 6 (E Maass)

[202] Frazer, *Folk-Lore in the Old Testament*, I 66

[203] "According to the natives of Nias [off the coast of Sumatra] the personage who was charged by the creator with the duty of putting the last touches to man broke his fast on bananas instead of on river-crabs, as he should have done, for had he only eaten river-crabs, men would have changed their skins like crabs, and like crabs would never have died But the serpents, wiser in their generation than men, ate the crabs, and that is why they are immortal." — Frazer, *The Scapegoat*, p 303

[204] *Folk-Lore in the Old Testament*, I 68 See also his captions, "The Story of the Cast Skin," pp 66–74, and "The Composite Story of the Perverted Message and the Cast Skin " pp 74–76.

Frazer seems to have missed the following classical story. A tradition says that Zeus, in return for aid in punishing Prometheus for stealing fire from Hephaestus, bestowed upon his helpers a magical means of warding off old age. This they placed upon an ass which they sent ahead of them. It was summer and the ass, becoming thirsty, went to a spring, but a serpent on guard there refused to permit it to drink except in exchange for the burden. The terms were agreed to. The ass drank, the serpent secured the ability to slough old age, taking in addition the thirst of the ass.[206]

The phoenix, which has already been mentioned in connection with longevity of animals, is generally described as dying and giving rise to another phoenix, but an occasional account does speak of its renewal of youth,[207] or of its casting off its old age.[208]

## THEORIES ABOUT BELIEFS

### *Longevity*

Both ancients and moderns have attempted to explain these popular beliefs. The author of the *Longaevi*, a work traditionally attributed to Lucian, regards the long life of Arganthonius as a fable. Pliny[209] thinks that some tales of longevity are outright lies and that they are due to peculiarities of chronology, such as the year of three months among the Arcadians. St Augustine elaborates this idea.[210]

A Greek whose views are recorded by Plutarch[211] thinks that in connection with fabulous ages the word *genea*, which is frequently translated 'lifetime,' means 'year.' Herodotus[212] says three *geneai* make a century There was an oracle to the effect that the Cumaean Sibyl was to live ten *geneai* [213] Passages already quoted give her life as 1000 years, but the Sibyl [214] herself interpreted it as a *saeculum*, in the sense in which the term was used in connection with the *ludi saeculares*, which were held every 110 years. Juvenal [215] regards a *saeculum* as a third of a century Ausonius [216] gives 'three times two and nine times ten years' as the lifetime of men who attain fulness of age, while Solon's celebrated poem [217] makes ten periods of seven years each In addition to differences in the meaning of *genea*, the attempt to translate the word into a definite number of years or vice versa, the translation of a definite number of years into *geneai*, would lead to further confusion

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[205] *Op. cit.*, I: 45–52. See his paper on "The Serpent and the Tree of Life," *Essays and Studies Presented to William Ridgeway*, pp. 413–426.

[206] Aelian, *De Nat. Anim.*, 6. 51.

[207] Nonnus Dionys., 40. 398. Λύσας δ' ἐν πυρὶ γῆρας, ἀμείβεται ἐκ πυρὸς ἥβην. Cf. Pomp. Mela, 3. 8, *ad finem*; Stat., *Silv.*, 2. 4. 36.

[208] Lucian, *De Mort. Peregr.*, 27.

[209] *Nat. Hist.*, 7. 155.

[210] *De Civ. Dei*, 15. 12.

[211] *Mor.*, 415 D–416 C.

[212] 2. 142. The *Etymologicum Magnum*, s. v. *genea*, gives 29 years.

The absence or loss of written records helps the mythologizing process Nowhere is this better illustrated than in the history of the kingship at Rome. The seven kings reigned from 753 to 509 B C , an average of 34 years for each one Such a thing cannot be paralleled in the history of mankind and is absurd on the face of it Forty men who occupied the ducal chair in Venice through five centuries had an average reign of twelve and a half years To give but one instance of a *reductio ad absurdum*, if we trust the tradition, "Tarquin the second must have approached the venerable age of 70 when he rose against his father-in-law, must have been more than 90 when he besieged Ardea, and 108 or 110 when he fought in the battle of Lake Regillus " [218]

Even in modern times the clock of the age of septuagenarians and octogenarians is set too fast and it takes but a few years for them to become centenarians, a situation aptly designated by the word centenarianism [218a]

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[213] Phlegon, in Mueller, *Frag Hist. Graec* , III. 610.
[214] *Loc. cit*
[215] 10. 248–249
[216] Book 7, *Ecl.* 5
[217] Bergk, *Poetae Lyrici Graeci*, Frag 27 (3)
[218] Ihne, *Early Rome*, pp. 55–56.
[218a] See William J Thoms, *The Longevity of Man Its Facts and Its Fictions* (London, 1879)

Theophrastus [219] is said to have accused Nature in his last moments because she had granted a long life to deer and crows, to which it means nothing, whereas she had granted a short life to man, to whom life means a great deal. An illiterate or imaginative person reflecting in this vein might easily go a step farther and create stories telling how man did at one time actually have the boon of longevity or immortality and finally lost it. The Greek tale of the way the means of averting old age was lost to a serpent is paralleled among several peoples.[220]

Records of long-lived people are doubtless in many instances an expression of the yearning of people to live as long as possible, in spite of the frailties and weaknesses incident to old age.[221] Man idealizes the past. It is easy for him to believe that in the distant past or in distant countries things actually have been as he would like them to be.

Pliny [222] thinks that much of what Hesiod has to say about the long life of the raven, deer and crow is fabulous and regards as still more extravagant his words about the phoenix and the nymphs. Another doubter, or rather scoffer, is Aristophanes,[223] who by way of jest changes the number of generations of the crow from nine to five. Macrobius [224] speaks of the reputed ages of the raven and the crow as mythical. Aristotle did not believe that the deer was long-lived.[225] He speaks of the skin of the snake as the "so-called old age."[226] A certain pedant, not believing that crows lived two hundred years, went and bought one to find out for himself.[227]

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[219] Cic., *Tusc. Disp.*, 3. 69. The contrast between the happy lot of snakes and the plight of mortals is noted by Nicander, *Theriaca*, 355–356.

[220] See Frazer, *The Scapegoat*, pp. 302–305.

[221] Compare Pliny, *Nat. Hist.*, 7. 168. Natura vero nihil hominibus brevitate vitae praestitit melius. Hebescunt sensus, membra torpent, praemoritur visus, auditus, incessus, dentes etiam ac ciborum instrumenta, et tamen vitae hoc tempus adnumeratur.

[222] *Nat. Hist.*, 7. 153. See too Plut., *Mor.*, 416 A.

[223] *Aves*, 609.

[224] *Sat.*, 7. 5. 11.

[225] *De Anim. Hist.*, 6. 29, 578 b 25. See too Aristotle, *Hist. Anim. Epit.*, 2. 492 L (*Suppl. Aristot.*, I. 1. 128, 3).

[226] *De Anim. Hist.*, 5. 17, 549 b 26.

[227] Hierocles, *Facetiae*, No. 19.

The belief that one might lengthen his days by eating the flesh of long-lived animals *is* based of course upon sympathetic magic It will be recalled that Achilles was fed on the inwards of lions and wild boars and the marrow of bears by his teacher Chiron,[228] obviously in order that he might acquire the courage and strength of these animals [229]

I am inclined to believe that the stories of the killing of aged men may be reminiscences of days when the old and feeble were put to death during migrations and war as an alternative to abandoning them or allowing them to fall into the hands of the enemy Such things have happened among Brazilian tribes [229a]

### *Immortality*

Lore of immortality upon earth aroused still greater incredulity Some persons tried to explain away the story of Endymion by saying that he hunted during the darkness animals that sought their prey by night and that he spent the day resting in a cave, wherefore it was thought that he slept all the time Others said that he was the first to become interested in celestial phenomena and that as the moon engrossed his attention by night he slept by day [230] Still others declared that he was only a man very fond of sleep, and that from his addiction to it arose the proverb, 'Sleep of Endymion,' to designate those much given to sleep or those doing anything in a sleepy manner [231] Of course the tale of Endymion was occasionally used purely as a literary embellishment,[232] although not so effectively as Keats employed it in modern times

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[228] Apollod , *Bibl* , 3 13 6 See Frazer's note *ad loc*

[229] See "Homoeopathic Magic of a Flesh Diet," pp 138–168, in Frazer, *Spirits of the Corn and of the Wild*, Vol II

[229a] One such instance is quoted in *The World's Work* for July, 1925, p 319 I have not been able to consult the original source of the statement, *Discoveries on the River of Death*, by F W Smith

[230] Likewise some people said that the sleeper Epimenides spent considerable time gathering herbs. See Diogenes Laertius, 1 10 3, and *Scholia Strozziana in Germanici Caesaris Aratea* (ed Breysig, Teubner, 1869), p 201

[231] *Apollonii Argonautica*, ed Merkel-Keil, p 487

[232] E g , by Cicero, *Tusc Disp* 1. 92. *Endymion vero si fabulas audire volumus* ; Theocritus, 15. 107, is equally frank in calling the story of Berenice a myth.

The immortality of Glaucus is ingeniously explained by Palaephatus. He was a special kind of fisherman, a diver. On one occasion after he had dived he was not seen for several days. When asked where he had been, he replied, "In the sea." He spent so much time in the sea that he was finally called "marine Glaucus" or "Glaucus of the sea." Finally he encountered a marine monster and was killed. When he failed to reappear, the story was created that he was making his home in the sea and living there forever.[233]

People said likewise that the tale about Tithonus was a fable, or an allegory, or a nature myth.[234] Frazer[235] suggests that the basis of the tale is the popular lore about the sloughing of its shell by the cicada and its consequent immortality.

The gods were called immortals. Though it was said that the deities could not procure death for themselves even though they wished it,[236] and that Zeus was a ruler to whom time brought not old age,[237] nevertheless the grave of Zeus was shown to visitors in Crete at about the first century of our era.[238] There were also graves of other gods.[239] We have seen that the Homeric *Hymn to Aphrodite* states that the gods do feel old age. Thinking men placed further limitations upon the so-called omnipotence of the supreme deity by denying to him the ability to make mortals immortal and to restore life to the dead.[240]

The purpose of fire in the rites of immortality is expressly stated by Ovid[241] and by Apollodorus.[242] It was to purge the body of its mortal element. An elaboration of the idea is to be found in Iamblichus.[243]

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[233] Palaephatus, 27 (28)

[234] Tzetzes, *ad Lyc Alex.*, 18.

[235] On Apollod., *Bibl.*, 3 12 4–5 (vol II, p 44)

[236] Plin., *Nat Hist.*, 2 27

[237] Soph , *Antig.*, 609–611.

[238] Callim., *Hymn to Zeus*, 9 *sqq* , Diod. Sic , 3 61 2, Lucian, *Philopseudes*, 3, *idem*, *Juppiter Tragoedus*, 45; *idem*, *Philopatris*, 10, Cicero, *De Nat. Deor* , 3 53, Porphyry, *Vita Pythagorae*, 17 Pomp Mela, 2 7 12, Min. Felix, 21 1, 8, Lactantius, *Divin. Inst* , 1. 11 I found these references in Frazer, *The Dying God*, p. 3

[239] Frazer, *The Dying God*, pp 3–4

[240] Plin., *Nat Hist* , 2. 27

[241] *Fasti*, 4. 554: . . . *humanum purget ut ignis onus*

[242] *Bibl.*, 3. 13. 6.

[243] *De Mysteriis*, 5 12

> Fire destroys the material part of sacrifices, it purifies all things that are brought near it, releasing them from the bonds of matter and, in virtue of the purity of its nature, making them meet for communion with the gods So, too, it releases us from the bondage of corruption, it likens us to the gods, it makes us meet for their friendship, and it converts our material nature into an immaterial [244]

It is noteworthy that the ancients recognized so clearly the cleansing — one is tempted to say sterilizing — effects of fire and heat.[245]

## *Life-Token and Invulnerability*

As already pointed out, stories in which the life-token plays a part are obviously based on sympathetic magic One writer is strongly inclined, however, to believe that the fiction underlying the story of the vein of Talos originated from the *cire perdue* method of hollow-casting in bronze [246]

In the article already quoted (p 54) Berthold has shown that the traditions in the older Greek writers either make no mention of the invulnerability of the many heroes and other beings who in the later literature are said to have been immune to wounds, or else, as is generally the case, describe them as having been actually wounded. Their invulnerability was a tradition which grew up as a result of various aspects of the mythologizing process

The invulnerability of Ajax may be explained as sympathetic magic. We are told by Tzetzes [247] that the lion which Heracles strangled was invulnerable to iron and all sorts of missiles The virtues and the peculiar qualities of many things are imparted to objects which they touch. When the skin of the lion was wrapped about Ajax he became invulnerable wherever contact was effected.

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[244] Frazer's translation in *Adonis, Attis, Osiris* [3] (1914), I 181. In *The Classical Review*, VII· 293, Frazer says "These stories probably reflect an old custom of passing a new-born child over the flames or keeping it over a smouldering fire for some time, in order to ward off evil influence "

[245] The same idea is evidently present in the ceremonies of rejuvenation by boiling.

[246] Cook, *Zeus*, 1: 723–724. See note 132 of this paper

[247] *Ad Lyc. Alex.*, 455.

### *Rejuvenation*

The activities of Medea aroused the scepticism of antiquity One mythographer says that there is no proof of her ever having boiled people back to youth He does say that she was the first who found flame-colored and black flowers suitable for dyeing grey hair and changing it to a flame color or to black Again, she was the first to find the vapor-bath useful for man She gave a vapor-bath to patients only after having sworn them to secrecy, so that physicians might not learn of it The bath itself was called 'a boiling' A man who was 'boiled' became more nimble and healthier When people saw Medea's cauldron and fire, they were persuaded that she had boiled her patients Pelias, who was old and feeble, could not stand the ordeal and died during the treatment [248]

In describing the wonders of the hot-baths at Baiae a poet of the *Latin Anthology* [249] uses language that would be suitable for the story of Medea

Hic senibus florens virtus renovatur anhelis
His fessos artus viva lavacra fovent

Rejuvenation by boiling has been ingeniously explained as a survival of a ritual of rebirth by candidates for initiation into some religious cult [250] It is supposed that the Titans, after killing Dionysus as a kid, boiled him in milk with a view to his being ceremonially reborn [251] "The mystic who aspired to be one with his god underwent, or at least claimed to have undergone, a like ordeal " [252] It is held likewise that the references to rejuvenation in Aristophanes reflect a rite of regeneration. The accounts of the boiling of Pelops, who is taken to be simply a double of Pelias, are explained in the same way.[253–254]

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[248] Palaephatus, 43 (44) This reference is to be found most conveniently in *Mythographi Graeci*, III, Part 2, pp 64–65

[249] No 211 in Riese's edition.

[250] See Cornford, *The Origin of Attic Comedy*, pp 89–93

[251] *Op cit.*, p 89 On the bath of boiling milk as a means of ritual rebirth, see Cook, *Zeus*, I 677, 785

[252] *Op cit* , p 89

[253] See Cornford's chapter on the "Olympic Games" in J. E Harrison's

Snakes that have shed their skins look rejuvenated The savage believes they *are* rejuvenated "From such observations and fancies it is an easy step to the conclusion that man might similarly take a fresh lease of life and renew the lease indefinitely if only he could contrive like the animals to get a new skin This desirable object the Mexicans apparently sought to accomplish by flaying men and wearing their bleeding skins like garments thrown over their own By so doing persons who suffered from cutaneous diseases hoped to acquire a new and healthy skin, and by so doing the priests attempted not merely to revive the gods whom they had just slain in the persons of their human representatives, but also *to restore to their wasting and decaying frames all the vigour and energy of youth* "[355]

This paper is intended to show one aspect of the inner life of the ancients In view of our own efforts to retain youth and to extend life, it is not without historical interest Advertisements the country over are urging women to "Keep that schoolgirl complexion" Women fail to age after twenty-five or thirty Men proudly proclaim that they are seventy or eighty years young. We are even resorting to surgical means of restoring youth The ancient aspirations seem to be as pronounced as ever,[356] but in general they find expression in more natural and more wholesome ways Physicians are now prescribing common sense instead of magic

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*Themis*, pp 243 ff "The Myth of Pelias and that of Pelops have been shrewdly and, I believe, rightly interpreted by Mr F M Cornford as presupposing a ritual of regeneration or rebirth" — Cook, *Zeus*, I 679

[354] In this paragraph I am of course omitting all the evidence for these conclusions.

[355] Frazer, *The Scapegoat*, pp 304–305.

[356] There are four books of fairly recent date which would doubtless have been widely read had they appeared in antiquity

*The Prolongation of Life*, by Élie Metchnikoff Putnam's, 1908
*Old Age Deferred*, by Arnold Lorand F A Davis Co, Phila, 1911
*The Abolishing of Death*, by Basil King Doubleday Page & Co, New York, 1923
*Rejuvenation*, by Norman Haire. The Macmillan Co, New York, 1925 This gives case-histories of the work of Steinach, Voronoff and others

A modern idealization of youth that enjoys universal sympathy and approval is the story of Peter Pan, the boy who wished never to grow up  Though we idealize youth as much as did the ancients, we do not forget that old age too has its charms  "Grow old along with me, The best is yet to me, The last of life for which the first was made," is a sentiment that could hardly have found utterance in antiquity.

UNIVERSITY OF MICHIGAN

# A DOMINANT BROWN PERICARP COLOR IN MAIZE *

E G ANDERSON

A BROWN modification of red pericarp color in maize has been reported by Emerson (1921) and further discussed by Anderson and Emerson (1923) Its factorial relations are as follows

$P$ $A$ — red
$P$ $a$ — brown
$p$ $A$ — colorless
$p$ $a$ — colorless

The effect of the factor pair $Aa$ is to modify the nature of the pigment, whose presence and distribution are determined by the $P$ series of allelomorphic factors (Anderson, 1924). The dominant $A$ gives a red pigment, the recessive $a$ gives a brown The factors $A$ and $P$ are independent

Among strains of brown pericarp from other sources one has proved to be dominant to red This strain was derived from a few seeds of brown pericarp maize from Ecuador obtained through Dr. D F. Jones of the Connecticut Agricultural Experiment Station in 1917 These seeds produced plants too late for maturity at Ithaca, New York, but pollen was obtained which made possible a cross with an early maturing strain Three $F_1$ plants were grown, two of which had brown pericarp The third plant had red pericarp. Both of the brown pericarp plants were outcrossed to white or red-cob white giving brown, red and white (including red-cob white) pericarps Lack of ma-

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* Paper from the Department of Botany of the University of Michigan, No. 284, reporting research conducted by the author while holding appointment as National Research Fellow in Biology

tunity prevented an accurate classification of most of these plants.

Seven red pericarp plants of this generation outcrossed to white or red-cob white gave a total of 264 red and 242 white or red-cob white. No browns appeared. Another red pericarp plant selfed gave only reds and whites.

Five brown pericarp plants outcrossed to white (Table I) gave a total of 132 brown, 115 red, and 186 white. This ratio departs rather widely from a 1 : 1 : 2 ratio largely through a deficit of whites. The departure from equality of the ratio of brown to red is only 1.6 times the probable error.

## TABLE I

### PROGENIES OF OUTCROSSES OF BROWN × WHITE TO WHITE

| Pedigree Numbers | Brown | Red | White |
|---|---|---|---|
| 3587 | 3 | 2 | 5 |
| 3588 | 6 | 5 | 7 |
| 3589 | 13 | 4 | 14 |
| 3590 | 8 | 17 | 13 |
| 3596 | 26 | 27 | 46 |
| 3597 | 45 | 32 | 68 |
| 3717 | 31 | 28 | 33 |
| Total | 132 | 115 | 186 |

One brown pericarp plant from the cross of brown by red-cob white was outcrossed to white, giving a progeny of 34 brown, 20 red, 34 brown-cob white and 33 red-cob white. This is a close approximation to the 1 : 1 : 1 : 1 ratio expected on independent distribution of the *P* factor for pericarp and the factor responsible for brown pigmentation.

From the foregoing data this brown pericarp color appears as a dominant to the ordinary red color and is probably due to a single factor difference. This factor is independent of the *P* series of allelomorphs for pericarp color or at least not closely linked. Brown pericarp appeared on dilute sun-red, sun-red, dilute purple, and purple plants in contrast to the recessive brown described by Emerson (1921).

Tests carried out on a brown variegated strain, also of South American origin, have given results which parallel those reported above. The brown color proved dominant to red. Selfs and outcrosses of brown variegated plants gave red variegated plants as segregates. The red variegated plants bred true or segregated into red variegated and white. It has not yet been determined if the factor responsible for the brown modification is the same as the one present in the brown pericarp race from Ecuador.

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# THE WILD ROSES OF THE MACKINAC REGION OF MICHIGAN *

EILEEN WHITEHEAD ERLANSON

DURING June and July, 1924, extensive collections of wild roses were made, chiefly in the northern parts of Emmet and Cheboygan counties, Michigan, by C O. Erlanson In August the writer joined him, and after a week in the same region we went over the Strait of Mackinac, and made further observations and collections in southeastern Mackinac County during the first half of September Since then several hundred loaned herbarium specimens have been examined, including good series of wild roses from Green Bay, Wisconsin, from around Duluth, and from the northwest shore of Lake Superior, Ontario These collections show that many of the numerous forms found in the Mackinac region of Michigan are widespread throughout the northwestern Great Lakes shore, they are, therefore, not of merely local interest.

The northwestern Great Lakes lie in the region of northeastern hardwoods, with scattered areas of northeastern pine forest and of spruce-fir forest. All three types of vegetation are included in the three Michigan counties visited last summer The jack-pine plains of the south part of Cheboygan County yielded some extremely interesting roses, including *Rosa palustriformis* Rydberg A large part of the beech-maple area, since being lumbered and burned over, is an arid waste of aspens where an occasional plant of *Rosa blanda* Ait. is seen Roses do not grow in deep shade and are, therefore, absent from the coniferous woods except for a few weak, straggling plants scattered along the margins or in the pathways Single plants of *Rosa acicularis* Lindl. were seen now and again in such situations, but they seldom bore any flowers The rose flora is chiefly characteristic of the sandy beaches and of the beach thickets along the lake shores. It consists mainly of the two frequent species, *Rosa blanda* Ait and *Rosa acicularis* Lindl *Rosa palustris* Marsh (*R carolina* L 1762, not L 1753) forms occasional large thickets in the swampy flood-plains of streams, on stream banks or in the moist soil of a fosse near a lake shore throughout the region

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* Paper from the Department of Botany of the University of Michigan, No. 238.

No exotic species were observed last summer, but Dodge (13) reported *Rosa rubiginosa* L from Mackinac Island and Mackinac County The University Herbarium contains a specimen of *Rosa pimpinellifolia* L (*R spinosissima* L in part) from Emmet County, collected along a roadside west of Mackinaw City by Dr J. H Ehlers in 1916 Dr Ehlers also collected an unusual form on the railway bank north of Pellston, Cheboygan County, in 1920. This specimen is low and herbaceous, with the stem densely bristly, terminating in a corymb of flowers It evidently belongs to the group of *Rosa suffulta* Greene and may have been carried in by a railway train It was hunted for last summer, but without success

In the field I was immediately struck by the apparently "intergrading forms" between *R acicularis* and *Rosa Bourgeauiana* Crépin, and, to a lesser extent, between *R acicularis* and *R blanda* It is probable that hybridization has occurred in the past and is still freely taking place Occasional groups of plants were observed, evidently clones, which exhibited a large percentage of small green abortive hips in August, a possible indication of hybridization These hips fall off easily and would be very apt to be missing on herbarium specimens Many of the anomalous forms of *R blanda* which appeared to resemble *R. acicularis* in certain characters bore full crops of hips crowded with achenes. There is no reason to suppose that many of the natural hybrids are self-sterile On the contrary the $F_2$ generations from oft repeated crosses between the species of Rosa which occupy the same habitat and flower at the same season are no doubt partly responsible for the interesting series of forms found

The roses of this part of Michigan show evidence of the occurrence of definite similar sets of micro-species within different species groups, as found in European rose species by Almquist (1), Harrison (16) and others Crépin drew attention to the phenomenon in 1866 (7), calling it "parallel variation" There is reason to believe that many species groups (collective species) in North America show two series of forms, one with rounded hips and the other with elliptical or tapering hips, another pair of forms commonly occurring has one member with pubescent leaflets and the other with glabrous leaflets This will be discussed further under the individual species It may be that the species are subject to definite mutations which produce, in each, forms with glabrous leaflets and sepals, gland-compound teeth, and tapering hips Mr C C Deam (12) believes from his observations in the field that such characters are largely influenced by the habitat It is, therefore, of first importance to test this hypothesis experimentally in the garden as has been done with Rubus by Brainerd and Peiterson (3) Probably both hybridization and mutation are taking place in the wild roses around the Great Lakes I saw some indication of there being a shade form of *R acicularis* var *Bourgeauiana* Crépin with pubescent, glandless leaflets and simple non-glandular serrations A specimen, without flowers, probably *R acicularis*, collected by Dr Ehlers in a Thuya bog near Burt Lake has thin almost glabrous leaflets without glands and with very narrow stipules The most glandular specimen of *R acicularis*, with leaflets resinous beneath, was found at Prentis Bay growing at the side of a lumber road in a fir-cedar stand where it could not receive much sunlight

Most of these roses in the living state possess glaucous leaves This is a characteristic difficult to detect in dried specimens

In this account I have treated anomalous specimens under the species they most nearly resemble. I feel that it is impracticable to do anything else than name such dubious types as varieties of the most similar specific type or, in the case of the most outstanding ones, to give them binomial names One's guess at a possible mode of origin should hardly become a part of botanical nomenclature It is necessary that these forms be grown and tested for hybridity and that the suspected cross be made in the gardens to re-create the natural hybrids, before an authoritative nomenclatural statement of hybridity can be made.

At the end of the last century Dr. J H Schuette made extensive field-studies of the wild roses along the shore of Green Bay, Wisconsin, and distinguished several distinct varieties of *R. blanda* and of *R palustris* In his one short published note (23) he says that "separating into good species or distinguishable varieties is the best way of advancing our knowledge of this group" The confusion arising from the ever increasing number of species can be avoided by the adoption of a trinomial system as advocated by Hall and Clements (15) Recognized species are then retained and the forms or segregates are described as varieties, thus keeping relationships clear

Writing on hybridism in the New Zealand flora, Cockayne (5) remarks that, since "a flora is essentially an instrument for the identification of any plant growing wild in the area with which it deals, hybrids should bear names and be described equally with species" This has been done in several modern European monographs Rehder (19) is naming the known rose hybrids at the Arnold Arboretum, inserting the parent names at the head of the description. It is unfortunate that he does not adhere, in every case, to the usual convention of placing the name of the seed parent in front of that of the pollen parent. Hooker (17) pointed out long ago that it is very easy to dub a difficult specimen a hybrid. In this country, with all the conveniences of transportation, when a distinct rose specimen is found in a herbarium, an effort should be made to re-discover the form at the original locality so that it may be tested out in the garden

What is most needed in dealing with polymorphic groups such as Rosa is some idea of the range of variation within the species, either from experimental work or from good sets of complete specimens. This would guard against what Crépin called the "bush-mania." Intensive local studies are needed but we must also become familiar with the same forms from localities throughout their range to get a correct perspective of their relative importance Alphonse de Candolle (4) pointed out that "le danger de descriptions faites sur des éléments détachés de leur ensemble est au maximum quand on choisit pour études les fragments locaux d'un group complique et obscur, comme des *Rubus*, *Rosa*, *Hieracium*, *Salix*, *Mentha*, etc" A great weakness of the system of calling a new form "species A × species B" is that there is always the possibility of the original forms A and B being themselves hybrids — in fact studies on pollen-sterility in the genus (Cole, 6) indicate hybridity in the majority of rose species

## THE GROUP OF ROSA ACICULARIS

The majority of the plants of this group observed in the Mackinac region had the leaflets pubescent and glandular-granuliferous beneath, gland-compound teeth and subglobose hips Plants corresponding to the descriptions of *R acicularis* do occur, some without any glandular granules on the leaflets After many years of work M Crépin reduced his *R. Bourgeauiana* to a variety of *R. acicularis*, and there is no doubt that J D Hooker would have done so I have also been unable to discover any character which gives a reliable specific difference between *R acicularis* and *R. Bourgeauiana*, as diagnosed by Dr Rydberg in the *North American Flora.* Even the hip-form gives a good series from long and narrow, through pyriform to subglobose, the two latter forms I have seen occurring on the same specimen According to Cockayne the very existence of such a series is an evidence of crossing between two species For one who tries to determine the specimens in this group with Dr Rydberg's key (20), the situation is complicated by the fact that it is possible to find, within a small area, specimens with the hip pyriform or subglobose, leaflets glandular or non-glandular, teeth gland-compound or simple, these characters being combined in every possible way. Some of these combinations, such as elliptic hips with glandular, gland-serrulate leaflets, are rare in the Mackinac region, whereas others are common. There are also glabrous forms in this group, although these are rare. No completely glabrous-leafed form has been seen from this region, but the amount of pubescence varies widely Some seedlings from pubescent types of *Rosa acicularis* at the Botanical Garden have entirely glabrous leaflets, but others are sparsely pubescent in varying degrees The same plants must be observed at maturity before the observations can be interpreted

Matthews (18), working on the assumption that hybridization and segregation take place in the European wild rose forms, attempted an analysis of some British species on the basis of a few separate characters used in classification. He considers these as pairs of unit characters, for example, hairiness of leaflet *vs* glabrousness, biserration *vs* simple teeth, and treats them as though they were simple Mendelian allelomorphs It is interesting to find that in several cases all the possible combinations of two, three or four pairs of such characters have been found in the field and named This author also advocates a return to the Linnean conception of species in Rosa, the various combinations of unit characters to be denoted by a purely symbolical method, until we have proved whether or not the elementary species are stable

I tried out this method with the specimens of the *R. acicularis* group from the Mackinac region, choosing the characteristics used to separate the forms in Rydberg's key, omitting the presence and absence of glandular granules on the leaflets, since almost all our specimens possess them in varying degrees

In Table I, *R* represents a plant possessing a round hip and *r* an elliptic or pyriform hip, *P* represents pubescent leaflets and *p* glabrous leaflets, *S* represents doubly gland-serrate leaflets and *s* leaflets with eglandular teeth It is to be understood that these symbols have no genetical significance, since we know nothing of the way in which these characteristics are inherited I found that plants corresponding to four of the eight possible combinations grew in the Mackinac region, but that much confusion exists as to their respective names, and that two others have been recognized elsewhere.

## TABLE I

Combinations of Three Sets of Characteristics in the Group of Rosa acicularis Lindl

Hip round, R, pyriform or elliptic, r
Leaflets pubescent, P, glabrous, p
Gland-compound teeth, S, eglandular teeth, s

| Combinations | Name of Form |
|---|---|
| 1 PRS * | var Bourgeauiana Crépin (leaflets glandular beneath) |
| 2 PRs * | var rotunda, n var (leaflets not conspicuously glandular) |
| 3 Prs * | var Sayiana, nom nov (leaflets not conspicuously glandular) |
| 4 PrS * | var lacorum, n var (leaflets conspicuously glandular) |
| 5 prS | R Engelmanni (leaflets conspicuously glandular) |
| 6 prs | |
| 7. pRS | |
| 8 pRs | |

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* These forms are found growing in the Mackinac region *Rosa acicularis* in its typical form does not appear in this Table because it is not glandular-granuliferous

**Rosa acicularis Lindl** — Two collections were made of plants with the formula *Prs*, which had no trace of glandular granules on the leaflets These were Cheboygan County, Douglas Lake, 1924, *C O Erlanson*, No 88, Mackinac County, Scotty Bay, 1924, *C O and E W Erlanson*, No 757 B

**Rosa acicularis var Bourgeauiana Crépin** — Bull Soc Bot Belg, 15 30 1876 — The formula *PRS* corresponds to this variety, having subglobose hips, with a very short neck, leaflets with pubescence and glandular granules beneath (varying from sparse to dense), and the teeth doubly gland-serrate The shape of the leaflets varies greatly, as does their size In some specimens from the Mackinac region the lateral leaflets are sessile, in others they possess distinct petiolules 1–2 mm long The following specimens of this were collected in the Mackinac region. Emmet County, Big Stone Bay, 1924, *C. O Erlanson*, Nos. 325, 551, 572, 576, 585, Cheboygan County, Black Lake, 1924, *C O Erlanson*, No 518, Mackinac County, Whitefish Point, Prentis Bay, 1924, *C O and E. W Erlanson*, No 664 (Botanical Garden, University of Michigan, No 6005), Scotty Bay, 1924, *C O. and E W. Erlanson*, Nos 757 A, 772

A common form closely related to *R aciculars* var *Bourgeauiana* possesses almost eglandular leaflets (glandular granules if present being small and sessile) with simple non-glandular teeth If specimens are examined in flower, when the final shape of the hypanthium is difficult to judge, there is an even chance that they will be classified under either *R aciculars* or var *Bourgeauiana* In Table I this form is represented by the formula *PRs*, which I have named var *rotunda*

R aciculaRis var. **rotunda**, n. var. — Low bush 2 5–7 dm high Stem usually densely bristly with straight unequal bristles, branches also bristly. Stipules adnate, 1–4 mm wide and 1–2 cm. long, with acute spreading auricles, either glabrous, glandular-granuliferous or finely pubescent on the back, varying on the same bush. Petiole and rhachis glabrous or pubescent, usually gland-hispid and often with a few setae Leaflets mostly 7, sometimes 5, often 9 on the turions, varying from elliptic and acute at both ends (e g 1 9 cm. long × 0 7 cm wide), to oval and obtuse at both ends (e g 4.5 cm. long × 3 cm. wide), 1–5 3 cm. long and 0.6–2 8 cm. wide, bright green and glabrous, or nearly so above, paler, glaucous, densely pubescent to villous beneath, glandular granules, if present, small and not noticeable to the naked eye nor to the touch Teeth simple, ciliate and eglandular, acute to ovate, ascending but convex on both margins Flowers solitary to 3 together Bracts conspicuous, ovate, glabrous or pubescent on the back with margins glandular-ciliate. Peduncles glabrous, rarely with a few weak hispid glands, from 1–2 3 cm long, mostly 1–1.5 cm. long, reflexed in fruit. Hypanthium glabrous, subglobose or round elliptic, rounded at the base, neck none or very short, 1 1–1.4 cm. in diameter, 1 2–1 5 cm high Sepals lanceolate, caudate-attenuate, 1–1 3 cm long, tips 0 5–2 cm. long usually about 1 cm. long, glabrous or short-pubescent on the back, usually with a few hispid glands, erect and persistent in fruit Petals rose pink, 2–2.5 cm. long. The following specimens were collected in the Mackinac region of Michigan. Cheboygan County, North Fishtail Bay, Douglas Lake, 1924, *C. O. and E. W. Erlanson*, No. 628 (Bot. Gard , Univ. of Mich., No. 5892), Type, jack-pine plains, 1924, *C. O. Erlanson*, Nos. 444, 405, 407, EMMET COUNTY, Big Stone Bay, 1924, *C O Erlanson*, Nos 572 A, 575, MACKINAC COUNTY, Prentis Bay, 1920, *J H Ehlers*, No 1401, 1924, *C O. and E. W Erlanson*, Nos 664 A, Scotty Bay, 1924, *C O and E. W. Erlanson*, No. 757 (Bot Gard, Univ of Mich, No. 6006), Bois Blanc Island, 1914, *C K Dodge* (This variety often grows in close association with var. *Bourgeauiana* )

[ROSA ACICULARIOIDES Schuette — Specimens of *R acicularis* var *rotunda*, as well as those of *R acicularis* var. *Bougeauiana* with leaflets more pubescent than glandular beneath, will run down to *R. acicularioides* by the key in the *North American Flora*, but they differ from the description in not having corymbose flowers I have seen Schuette's original specimens of this form, now in the Herbarium of the Field Columbian Museum, and I am convinced that this is a form of *R blanda* possessing leaflets with glandular teeth. Notes by Schuette on one of his sheets of *R acicularioides* state that similar specimens sent by him to Crépin and Best were placed by them in the group of *R blanda*. The habit and leaflets of Schuette's specimens are not at all like those of *R. acicularis* The armature of the stem is similar to that of *R blanda* var *hispida*, and the ripe hips are smaller and more opaque than in the forms of *R. acicularis* ]

ROSA ACICULARIS var. **Sayiana**, nom nov — *R Sayi* Schweinitz in Keating's *Narr. Exped. Long.*, 2 388, 1824, not *R acicularis* var *Sayi* Rehder,[1] *Cycl. Am. Hort*, 1555, 1902 — This variety may not be distinct from *R acicularis Lindl*, but I have used it to cover any plants having the combination *Prs*, ellipsoid hips, pubescent leaflets with non-glandular, usually simple, teeth, also possessing at least some glandular granules on the under side of the leaflets. The leaflets of *R acicularis* in the Old World are said to be "always eglandular beneath" (Crépin, 10) We have the following specimens from the Mackinac region of Michigan CHEBOYGAN COUNTY, Douglas Lake and vicinity, 1924, *C O Erlanson*, Nos 92, 98, 353, 355, EMMET COUNTY, Cecil Bay, 1922, *J H Ehlers*, No 2166, 1923, No 2694, *C O Erlanson*, 1924, No 311

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[1] Rehder in establishing the name *R. acicularis* var *Sayi* does not cite *R. Sayi* Schweinitz as a synonym If he did, it would be technically justifiable to use Rehder's combination, even though it were impossible to place under it the round-hipped plants which he describes. It would likewise be in order to disregard the synonym which he does cite *R. acicularis* var *Bourgeauiana* Since he does *not* cite Schweinitz's name, the only solution of the difficulty seems to be to make a new varietal name Rehder's varietal name has to be interpreted by the description and by the synonymy he does give, rather than by the implied synonymy. It is here treated not as a synonym of *R. Sayi* Schwein, but rather of *R. Bourgeauiana*.

ROSA ENGELMANNI S Wats — No specimens belonging to the *R acicularis* group were found in the Mackinac region corresponding to the combination *prS* (Table I) Dr. Rydberg (22) states that the type of *R Engelmanni* has leaflets "without pubescence, but distinctly glandular-granuliferous beneath, usually double-toothed and with gland-tipped teeth" He also insists that it is a "purely Rocky Mountain species." Several plants in the Mackinac region were observed having elliptic hips, and the leaflets pubescent and densely glandular beneath, with distinctly doubly gland-serrate teeth (9) This form I have named var *lacorum*

R ACICULARIS var **lacorum**, n var — *R Engelmanni* S. Wats *Gard & For*, 2 376, 1889, in part but not as to type *R. acicularis* var *Engelmanni* Crépin, L H. Bailey, *Cycl Am Hort*, 1555, 1902 — Low bush 3–8 dm high Stem densely bristly; scattered bristles on the branches Stipules adnate, 1·5 mm wide, 1–2 3 cm long, with ovate, spreading auricles, usually glabrous and glandular-granuliferous on the back, the margins densely glandular-ciliate Petioles and rhachis glandular with stipitate glands, glabrous or pubescent, rarely with a few setae Leaflets 5–7, varying from elliptic and acute at both ends (e g. 3 5 cm long × 1.5 cm. wide) to oval and obtuse (e g 2 6 cm long × 2 1 cm wide), in length from 1 to 4 5 cm., in width from 0 9 to 2.3 cm, dark green and glabrous above, paler, glaucous, sparingly to densely pubescent beneath, with numerous conspicuous stipitate, resinous glands, doubly serrate with glandular teeth Flowers solitary to 3 together. Bracts, if present, conspicuous, ovate, glabrous and glandular-granuliferous on the back, gland-ciliate on the margin. Peduncles glabrous, or rarely with a few hispid glands, from 1 to 2 5 cm. long, generally reflexed in fruit Hypanthium glabrous, pyriform to oblong or elliptic, usually tapering at the base and with a distinct neck, in fruit 0.8–1 4 cm in diameter and 1 3–2 1 cm high Sepals lanceolate, caudate-attenuate, 0 8-1 2 cm long, tips 0 5-1 cm long, usually pubescent and gland-hispid on the back, but sometimes glandless or glabrous, erect and persistent in fruit The following specimens were collected in the Mackinac region of Michigan MACKINAC COUNTY, Scotty Bay, 1924, *C O and E. W Erlanson*, No. 761, (Bot Gard , Univ of Mich , No 6007) (TYPE), Prentis Bay, 1924, *E W Erlanson*, No 153, (Bot Gard , No 6008), Mackinaw City, 1922, *H H. Bartlett*, (Bot Gard , Univ of Mich , No 2592), Bois Blanc Island, 1913, *C K Dodge*, EMMET COUNTY, Cecil Bay, 1916, *J H Ehlers*, No 222, Big Stone Bay, 1921, *J H Ehlers*, No 1675, 1924, *C O Erlanson*, Nos. 555, 576 A, CHEBOYGAN COUNTY, Douglas Lake, 1924, *C O Erlanson*, No 88 A.

These five forms seem to be widespread in the northern central states and Canada, and, although they intergrade to some extent, they are well marked and should be looked for in the field throughout the wide range of *R acicularis* This is a circumpolar species and is apparently more frequent in North America than in Europe In the examination of herbarium material for these forms, it is always difficult, in flowering specimens, to judge from the hypanthium in the flower the shape of the ripe hips. It would be of great value if local collectors would tag a few rose plants with numbered labels and would collect the flowers, leafy branches, ripe fruit and turions from each individual plant for distribution to the herbaria of the country

There has always been difficulty in distinguishing some of the bristly forms of *R blanda* from *R acicularis*, although the ripe hips of the latter are bigger than in *R blanda* and possess in life beautiful pellucid flesh. The direction and general shape of the serrations of the leaflets are apparently good characters for separating the forms of these two species, and were stressed by Crépin (10). The serrations in the *R. acicularis* forms are coarse, open, directed outwards, with both sides of a tooth convex, in *R blanda* the serrations are directed forward, so that the outer side of each tooth tends to be convex and the inner concave. Dr. Almquist lays great stress on the characters of the leaf serrations in Rosa and says that glands are unreliable as diagnostic characters It is important, also, to notice that in the forms of *R acicularis* the lateral branches bearing flowers are short, under 10 cm long, while in *R. blanda* they are almost always over 10 cm. long

The *R. acicularis* forms are the first of the Mackinac region roses to come into flower. In 1924 they began to bloom about June 20 and flowering was over after the first week in July The flowers are large and showy, with petals often 3 cm long. By August 1, the hips were full size but green. They were ripe by mid-August.

## THE GROUP OF ROSA BLANDA AIT

*R. blanda* is a common species, especially along beach thickets and sandy shores It varies a great deal, apparently with the habitat. The leaflets of all the specimens collected in the Mackinac region were found to have at least some short scattered hairs on the upper surface, as well as beneath. Plants growing in the dry sandy soil of the aspen formation and the jack-pine plains tend to be unarmed, with slender stems and small leaflets varying from pubescent to glabrate. No completely glabrous form was found In the beach thickets and on sandy lake shores, *R. blanda* tends to produce thick shoots, often bristly, with leaflets densely pubescent on both sides Sometimes the underground stems send up shoots almost at the water's edge, which flower when only 1.2 dm high and often have 9 leaflets on most of the leaves Glandless forms often occur, either with no glands at all, or with glands on the stipules, the sepals being glabrous.

A form of *R. blanda* with white flowers was collected on Douglas Lake by *C. O Erlanson*, No 396 This is *R blanda* var. alba Schuette in herb (TYPE. Allonez, Brown Co Wisconsin, *J. H Schuette*, June 16, 1895. Herb. Field Columb Mus., sheet No 379,239.)

A form collected Sept. 7, 1924 (*Erlanson*, No. 767) on the shore of Scotty Bay, Mackinac County, bore many hips, all solitary and only 7-8 mm broad, spherical and crowned by gland-hispid erect sepals, with bases as large as the hip Specimens of this are now at the University of Michigan Botanical Gardens (accession No 6004)

Plants of *R. blanda* bearing oblong hips, tapering at one or both ends, corresponding to *R. blanda glandulosa* Schuette, were collected at several stations in Cheboygan County (Bot Gard, Univ of Mich, No. 5889). The distribution of glands on the rhachis, stipules, bracts and sepals varies a great deal, often on the same individual. This form has been found near Lake Michigan in Indiana by Deam I do not think it is necessarily a hybrid with *R acicularis*, as Dr Rydberg believes. Some plants were found the last week in August in a shady thicket on Douglas Lake (*Erlanson*, No 627) with scattered bristles on the main stem, bearing several half-ripe subglobose hips and many abortive ones which fell off easily This I suspected to be a hybrid, but the fruit sterility might be due to the shaded situation This also is being cultivated at Ann Arbor (Garden accession No. 5888).

Many bristly forms of *R blanda* are common near the shore in Mackinac County, corresponding to *R blanda* var *hispida* Farwell (14) (*Erlanson*, No 593) and also to *R blanda* var *subgeminata* Schuette (*Erlanson*, No 665), with "twin-prickles intermittent and irregular"

An interesting and puzzling form grows at the edge of a small Ammophila dune on the north shore of Douglas Lake (*Erlanson*, No. 637 ) It is about a meter high with the habit of *R blanda* and bears terminal corymbs of globose glabrous hips by the middle of August. The stem is strongly armed with stout curved prickles, only occasionally paired, while the shape and serration of the leaflets are much as in *R palustris* It approaches some of the specimens of *R. carolina aculeata* Schuette and might possibly be a hybrid between *R blanda* and *R palustris*, although the former begins to flower about July 1 and ceases to do so by the end of July, while the latter seldom begins to flower until the first week in August, or later Schuette particularly noticed that his var *aculeata* flowered from three to four weeks earlier than typical *R palustris*

### ROSA PALUSTRIFORMIS RYDBERG

Specimens in flower corresponding to the description of this species and resembling some of Schuette's specimens were collected July 20, by C. O Erlanson, No. 456, on the jack-pine plains five miles south of the town of Indian River, Cheboygan County Two or three plants were seen growing in slightly shaded dry sandy soil.

## THE GROUP OF ROSA PALUSTRIS

ROSA PALUSTRIS MARSH (*R carolina* of authors) occurs throughout the region, but is much less frequent than *R blanda* and the forms of *R acicularis* It seems to need fairly rich moist soil, a sheltered situation and adequate sunlight It was collected from several stations in Cheboygan and Mackinac counties The plants were nearly all four or five feet high, forming dense but small thickets

A specimen collected in flower by C. O Erlanson at the edge of a bog in Cheboygan County was completely unarmed except for a few bristles at the base of the main stems, its leaflets were short-pubescent above as well as densely fine-puberulent beneath It is probably **R palustris** var **inermis** (Schuette), n comb (Schuette used the varietal name in his herbarium under *Rosa carolina* )

The leaflets on all the specimens observed were only 5 or 7 to the leaf and were mostly small for the species Two plants from Cheboygan County (Nos 535 and 544) had leaflets varying from 0 5 to 3 5 cm only. All our specimens have the lower surface of the leaflets densely short-pubescent all over, except in one case. Many have some pubescence on the upper side also The specimens collected by Schuette around Green Bay resemble our specimens in leaf characters. Dr. Rydberg has suggested that there may be a northern race of *R palustris* with smaller densely pubescent leaflets (21)

*R palustris* is the last rose to bloom, in the Mackinac region. It begins to flower during the last few days of July and continues throughout August The flowers are large and showy, with petals usually deep rose and often 3 cm long

In this part of Michigan *R palustris* flowers late while *R blanda* is early Further south the former flowers earlier and often overlaps the flowering period of *R blanda* along the southern parts of the latter's range This reverses the state of affairs mentioned by Dr Harrison (16) where the late spring in Scotland brings the flowering periods of *R mollis* and *R pimpinellifolia* together, giving ample chances for hybridization Unless there are certain early-flowering races of *R palustris* in the northern part of its range, as Schuette's specimens seem to show, there is not much chance for hybrids of *R palustris* and *R blanda* to occur in the Mackinac region

Dr Almquist has found that the most important characters to use in classifying roses are the color and consistency of the leaves, the form of the leaflets, and the shape and direction of the teeth. The latter seems to be a reliable character in separating *R palustris* from all the related forms, as was pointed out by Crépin (8)

Counts made of the number of teeth per leaflet in rose specimens from the Mackinac region showed that in *R blanda* they vary from 15 to 40, the mean being 29 In *R palustris* the number of teeth per leaflet varied from 25 to 70, the mean being 52 The leaf serrations of the anomalous prickly form of *R. blanda* (No 637) from Douglas Lake numbered from 30 to 55 per leaflet, the mean being 42.

### ROSA CAROLINA L , 1753

Only one group of plants doubtfully referred to this species was found These are on a damp wooded bank at the edge of Douglas Lake on North Fishtail Bay The plants are about a meter high, unarmed except for straight, slender, paired, infrastipular prickles on the branches. On August 18 they bore small, green, subglobose hips, 8–10 mm in diameter, sparingly gland-hispid, with the sepals spreading Leaflets 5 to 7, 2 to 5 cm. long, with short scattered pubescence beneath (Bot. Gard , Univ. of Mich., No 5891)

This colony is not typical *R. carolina,* but resembles some of the forms of this species collected by Schuette in Wisconsin.

### THE GROUP OF ROSA SUFFULTA

The specimens collected July, 1920, near Pellston by Dr Ehlers, seem to be a form of *R suffulta* Greene, with densely glandular rhachis and bracts The specimens are in flower and possess an elongated hypanthium as in the type known as *R Bushii*. *R. suffulta* has not been observed again in the region and may have been a chance introduction Some member of the same group was reported as *R arkansana* by Beal (2) as having been collected at Harbor Springs, Emmet County, by C. F Wheeler, but I have not seen his specimens

### KEY TO THE ROSES FOUND OR TO BE EXPECTED IN THE MACKINAC REGION

- Achenes parietal, hips usually glabrous, sepals persistent in fruit.
  - No paired infra-stipular prickles
    - Stem unarmed
      - Hips subglobose . . *R blanda*
      - Hips pyriform *R blanda* var *glandulosa*
    - Stem bristly
      - Flowers in corymbs, flowering laterals 10 cm long or more
        - Hips subglobose
          - Leaflets simple-toothed *R blanda* var *hispida*
          - Leaflets glandular double-toothed *R acicularioides*
      - Flowers solitary to 3 together, flowering laterals under 10 cm. long
        - Hips pyriform or elliptic
          - Leaflets pubescent beneath, teeth simple
            - Leaflets not glandular-granuliferous beneath *R acicularis*
            - Leaflets glandular-granuliferous beneath *R acicularis* var *Sayiana*
          - Leaflets pubescent and resinous-glandular beneath, teeth gland-compound *R. acicularis* var *lacorum*
        - Hips subglobose
          - Leaflets pubescent beneath, teeth simple *R acicularis* var *rotunda*
          - Leaflets pubescent and glandular beneath, teeth gland-compound *R acicularis* var *Bourgeauiana*
  - Paired infra-stipular prickles on stem and branches *R palustriformis*
- Achenes basal, or mainly so in *R. palustris*, hypanthium and pedicels gland-hispid, sepals deciduous in fruit
  - Paired infrastipular prickles straight . *R carolina*
  - Paired infrastipular prickles curved .. *R palustris*
  - Plant unarmed . . . . *R palustris* var *inermis*

Specimens of all the roses of the Mackinac region cited by the writer have been deposited in the Herbarium of the University of Michigan In conclusion I wish to thank Professor H H. Bartlett for his helpful suggestions and encouragement during this work

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# A METHOD FOR DETERMINING SEED VIABILITY BY ELECTRICAL CONDUCTIVITY MEASUREMENTS

GEORGE L FICK AND R P HIBBARD

A STUDY of the viability or germinating power of seeds still continues to be interesting Several methods are now in vogue for determining viability Some are long, while others take a shorter period of time to obtain results The old-fashioned rag-doll and germinator methods are long In some cases nearly a month passes by before the germination tests can be considered as completed Usually several days have passed by before germination is completed in many genera and varieties of plants A quicker method has for some time been sought. Recently (1) viability tests have been made by means of determining the catalase content of the given sample of seed The method depends on the theory that the viability of a seed is proportional to its catalase content

Some years ago Peirce (2) found that the heat of respiration was greater in fresh one-year-old wheat seeds than in ten-year-old seed, and thus concluded that one could ascertain the viability of different known ages of seed by determining the temperatures they would develop in silvered Dewar flasks under conditions suitable for germination

The present work is based on the fundamental principle brought out by the work of Osterhout (3) who showed that there was a difference in conductivity of living and dead tissues of Laminaria The solutes diffuse outwardly more readily in dead material than in living material If a proportion could then be established between viability and electrical conductivity, one would have a rapid method for determining the percentage of germination of any sample of seed.

As a result of the study, which at this time must be considered as preliminary in nature, it is believed that a correlation has been found which is fundamental and which with further amendment and improvement can be practically used In the fall of 1923, aided by the liberality of the Ferry Seed Company in contributing a fellowship, the writers began the studies, the results of which were embodied in a thesis which was in partial fulfillment of the requirement for the degree of Master of Science for the junior author.

A description of the apparatus may be found in the thesis referred to above It is practically the same as used by Hibbard and Chapman (4) for measuring the conductivity of electrolytes The immersion type of electrolytic cell was used, this being thrust into the water in which the seeds were soaking Since temperature changes were found to produce marked differences in resistance readings, the beakers were placed in a constant temperature water-bath regulated to 25° C

Two kinds of seeds were used in this preliminary work as it was thought better to work intensively with two, than superficially with many sorts. Timothy and red clover were chosen as they represent two very different types of seeds — timothy having a very large endosperm and red clover none at all There were four lots of seed, timothy and red clover of the 1923 crop, timothy of the 1915 crop, red clover of the 1893 crop. It was originally planned to use the 1923 crop entirely, and to prepare samples of seed showing different percentages of germination by mixing proportional parts of artificially killed seed with the viable ones. In following this plan it was first important to determine how large or what weight of sample was finally to be used In most cases, and especially with timothy, 0.5 gram samples were desired Then 0 5 gram samples of any desired percentage of germination are easily made from the two samples (artificially killed seeds and seeds of high viability) by the use of a well-known formula.

This original plan was not followed out because it was shown that seeds killed artificially by dry heat cannot be used in making up samples of different-percentage germination. The following table shows that the solution from the two lots of artifically killed seeds, Lot I (73.9 percent viable) and Lot II (89.8 per cent viable), offer vastly different resistances to the passage of an electric current instead of, as would be expected, the same.

### TABLE I

SOLUTION RESISTANCES (IN OHMS) OF ARTIFICIALLY KILLED SEEDS

| Lot No | Test Number | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 1 (73.9 per cent viable) | 8,963 | 8,643 | 8,870 | 8,425 |
| 2 (89.8 per cent viable) | 11,983 | 11,982 | 11,883 | 11,852 |

Since, as shown above, it was not possible to use seeds artificially killed by heat, the range of germination was limited between 73.9 per cent and 89.8 per cent in the case of timothy. In the short time available it was impossible to get seed older than the 1915 crop. In using the foregoing formula, 0.5 gr samples of three intermediate percentages were made (75, 80, 85). Thus with the extremes there were five different sets. In the case of clover, an old sample from the crop of 1893 was finally secured. This showed 3 per cent germination. The 1923 crop gave 91.8 per cent germination. With these two extremes 1-gram samples of percentage germination varying in increments of ten per cent were made up (3.6, 10, 20, 30, 40, 50, 60, 70, 80, 90, 91.8).

The various methods attempted will now be briefly described. Since the work of Osterhout had shown that one could determine the resistance of the tissues themselves, it seemed logical to try first the method of measuring the resistance of the seeds. This method was beset with difficulties, when put into practice, and the results were erratic.

After this method was abandoned the matter of relative absorption and excretion of salts, as indicated by conductivity measurements, was considered as a possible means of determining seed viability Samples of seeds of definite weight were soaked in NaCl or KCl solutions of varying concentration for different lengths of time The seeds were then washed and placed in conductivity water, the immersion electrolytic cell was introduced, and the resistance of the water, salts excreted and the seeds, determined at definite intervals The method seemed unsatisfactory because again there was no constancy in the results, the technique was complicated and the time required was too much

The third method, which with several modifications was finally adopted, is based on the observed differences in relative outward diffusion of electrolytes from dead and living matter As first tried it consisted in putting a definite weight of seed into a clean Pyrex beaker of 125 ml capacity containing 100 ml of conductivity water The immersion type of electrolytic cell was introduced and after a lapse of half an hour the resistance of the water, excreted solutes and seeds (solution resistance) was determined The readings were continued at definite intervals The following table shows that the sample of lower germination had the least resistance, and that the greatest difference between the resistances of the two samples was at 10.43, or after the seeds had been in the water one half hour

## TABLE II

SOLUTION RESISTANCES (IN OHMS) AT 25° C OF TIMOTHY AT VARIOUS TIME-INTERVALS

| Lot No | A M | | | P M | | | |
|---|---|---|---|---|---|---|---|
| | 10 43 | 11 13 | 11 43 | 12 13 | 1 13 | 2 13 | 3 13 |
| Lot 1 (73 9 per cent) | 9,839 | 8,628 | 7,761 | 7,176 | 6844 | 0680 | 6410 |
| Lot 2 (89 8 per cent) | 16,447 | 13,883 | 11,776 | 11,462 | 9980 | 9105 | 8570 |

Other readings were made with the two lots of timothy to determine the constancy The readings for lot one varied from 9400 to 10,331 ohms, for lot two from 12,337 to 12,852 ohms These variations are not large when one takes into consideration three factors First, the different samples of seeds from the same lot do not have the same germination percentages The percentage germination of a sample of seed is found by taking an average of half a dozen or more small samples Again samples of different percentages would necessarily give different resistance readings Thirdly, the stirring was done by hand and the ‘personal error’ might make a difference All tests, that is, a comparison of the two lots of different germination percentages, were run in pairs, the second following three minutes after the first The following schedule, taken from the records, shows the details of the method finally adopted.

### SCHEDULE OF OPERATIONS

In every case the solution was stirred two minutes, the reading is the solution resistance

| | Lot 3, 0 5 gr | | Lot 4, 0 5 gm |
|---|---|---|---|
| 9 30 | Put in beaker with 100 ml conductivity water | 9 33 | Put in beaker with 100 ml conductivity water |
| 9 45 | Solution stirred | 9 48 | Solution stirred |
| 10 15 | Solution stirred and electrolytic cell immersed | 10 18 | Solution stirred and electrolytic cell immersed |
| 10 30 | Reading 56,635 ohms | 10 33 | Reading 38,387 ohms |
| 10 45 | Solution stirred | 10 48 | Solution stirred |
| 11 00 | Reading 40,185 ohms | 11 03 | Reading 22,706 ohms |
| 11 15 | Solution stirred | 11 18 | Solution stirred |
| 11 30 | Reading 26,999 ohms | 11 33 | Reading 13,755 ohms |
| 11 45 | Solution stirred | 11 48 | Solution stirred |
| 12 00 | Reading 19,187 ohms | 12 03 | Reading 9,740 ohms |
| 1 45 | Solution stirred | 1 48 | Solution stirred |
| 2 00 | Reading 10,770 ohms | 2 03 | Reading 4,076 ohms |

The readings in most cases were at a better ‘working level’ at the end of two hours than at the end of one hour or one and a half hours In other words, the resistance values were at a level so low that slight mistakes in weighing the sample or measuring the conductivity water did not produce too large errors and yet high enough for an appreciable difference to exist between the readings for the two lots

When the solution resistances of the samples of timothy seeds of various germination percentages were measured according to the schedule above, and run in triplicates instead of in pairs, the results appeared as shown in Table III

TABLE III

SOLUTION RESISTANCES (IN OHMS) AT 25° C OF TIMOTHY IN SAMPLES OF DIFFERENT GERMINATION PERCENTAGES

| Germination percentages | Number of tests | | | Average |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| 73.9 | 10,331 | 9,400 | 9,485 | 9,772 |
| 75.0 | 10,080 | 9,930 | 10,070 | 10,027 |
| 80.0 | 10,617 | 10,998 | 11,122 | 10,912 |
| 85.0 | 11,211 | 11,627 | 11,363 | 11,400 |
| 89.8 | 12,600 | 12,852 | 12,337 | 12,590 |

It is readily seen from the table above that there is a progressive increase in solution resistance with viability increase. There are some discrepancies, however. Several readings for a certain percentage viability are too high. This is to be expected. One specific case can be considered. In one test of the 73.9 per cent seed, a solution resistance of 10,331 ohms was found, which is not only higher than either of the other readings obtained for seeds of that viability, but also higher than any reading for the 75 per cent seed, and almost as high as the reading for the 80 per cent seed. This can be explained only by attributing it to a 'personal error' in technique, or by supposing that the particular sample of seed giving the higher reading was of higher germination than the average sample of that class. The latter is a very valid supposition, for, when the germination of the lots of seed was originally determined by sprouting, it was found that the different samples used would vary over a range of 7 per cent for Lot III to 22 per cent for Lot I. The germination of Lot I according to the average of 10 tests of 100 seeds each was 73. 9 per cent, the highest being 83 per cent, the lowest 61 per cent. This difference was obtained despite the very thorough mixing of seed lots prior to sampling. Thus it does not seem unreasonable to suppose that the sample giving the reading 10,331 ohms was of germination considerably higher than 73.9

per cent. More conclusive proof would have been offered in support of the correlation between electrical resistance and seed viability had it been possible to extend the range of germination percentages of the timothy samples. Very old seeds were sought in the hope of getting some of low germination, but with no success for the period of time at our disposal. The most important point brought out by the data is that a difference does exist between the solution resistance of seeds of high and low germination. That is the fundamental relationship that must form the basis of any future work that looks toward the practical application of this method in the determination of the germination percentages of any lot of seed.

The same method, with only a few modifications, was followed for measuring solution resistances of red clover. In this case the range of germination was from 3.6 per cent to 91.8 per cent. The results appear in the following table.

### TABLE IV

SOLUTION RESISTANCES (IN OHMS) AT 25° C. OF RED CLOVER SEED FOR DIFFERENT GERMINATION PERCENTAGES

| Germination percentages | Tests | | | | Average |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | |
| 3.6 | 9,173 | 9,182 | 8,056 | 8,609 | 8,770 |
| 10.0 | 8,417 | 8,200 | 9,007 | 7,955 | 8,395 |
| 20.0 | 8,989 | 8,618 | 9,441 | 8,208 | 8,814 |
| 30.0 | 9,979 | 10,504 | 9,428 | 8,000 | 9,478 |
| 40.0 | 9,557 | 9,015 | 11,413 | 8,770 | 9,689 |
| 50.0 | 10,976 | 10,832 | 10,504 | 9,126 | 10,360 |
| 60.0 | 9,500 | 9,619 | 12,120 | 9,820 | 10,265 |
| 70.0 | 12,776 | 11,436 | 12,625 | 10,231 | 11,767 |
| 80.0 | 11,514 | 11,933 | 13,385 | 10,621 | 11,863 |
| 91.8 | 13,427 | 14,300 | 14,529 | 15,291 | 14,387 |

It appears here also that the resistance increases with the germination. Again there are several discrepancies. Some readings seem too high, others too low. No more can be said regarding these than has already been said concerning the timothy readings When the results with red clover are put into the form of a graph, the resistance increase is concomitant with viability increase, with only two exceptions

The immediate object of this study was, not to develop a method whereby seed viability could be measured by electrical conductivity, but to attempt to discover a fundamental correlation between seed viability and electrical conductivity Once established, such a basic relationship might be put to practical use in the laboratories of seed firms as a quicker and cheaper means of determining the percentage of germination of any lot of seeds, than the present method of running germination tests

Some recommendations for future work are suggested below

1 All the stirring was done by hand To avoid possible error from this source a mechanical stirrer should be used Continual stirring would bring about a quicker drop in solution resistance to the 'working level'

2 It might be better to use larger samples, for then the germination would more nearly approximate that of the well-mixed lot from which it was taken

3 The average time of a reading at any period was two minutes Several times it happened that the readings were delayed and more than two minutes taken It would seem an advantage to draw off the solution from the seeds at the stated periods Then it would matter little whether the readings were made immediately or shortly afterwards

4 A new and less fragile type of electrolytic cell could be devised The present ones are difficult to clean prior to platinizing. An open cup of hard rubber would appear to be cheaper and less fragile and the electrodes would be easily cleaned

5 For future work old samples of seed of varying degrees of viability should be secured, so that no seeds shall have to be killed artificially When seeds that have varying degrees of viability are obtained, then their solution resistances could be compared with artificially mixed samples of the same germination percentages This seems a very important consideration, for at this time we are cognizant of this possible criticism, that

in the use of varying amounts of dead seed and viable seed to make up the various mixtures of increasing germination percentages (as in the case of red clover, 3 6, 10, 20, 30, 40, 50, 60, 70, 80, 90, 91 8), a rise in the solution resistances along with the increasing germination might naturally be expected A study of samples of known ages and for different germination percentages is therefore necessary The present study shows, however, that in all cases samples of seed of higher germination showed higher resistances than samples of seeds of lower germination

6 Seeds from various sections of the country, having the same viability would also be secured to see what influence the soil has on the electrolyte content or composition of the seed as indicated by comparative solution resistance measurements

In conclusion it may be said that these studies dealt with an attempt to determine seed viability by an electrical conductivity method Two kinds of seed were used timothy possessing a large endosperm, and red clover having none at all Three methods were studied (1) measuring the resistance of the seeds themselves, (2) comparing the relative absorption and excretion of salts, and (3) measuring the relative outward diffusion of electrolytes as indicated by conductivity readings The last method was adopted The data indicate that a correlation between electrical conductivity and seed viability exists, which with further improvement may be capable of practical application.

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# ON THE DISTRIBUTION OF THE WATER MOLDS, WITH NOTES ON THE OCCURRENCE IN MICHIGAN OF MEMBERS OF THE LEPTOMITACEAE AND BLASTOCLADIACEAE *

BESSIE B KANOUSE

A REVIEW of the literature of the Saprolegniales soon discloses the fact that but little attention has been given to the habitat distribution of the fungi in this order, especially in the two families Leptomitaceae and Blastocladiaceae Von Minden (7) comments on the lack of such data and cites Thaxter and Humphrey in North America and Cornu and Petersen in Europe as the only ones who have given us information on this subject Even in their reports the matter of distribution is usually mentioned only in connection with separate collections with no special attention being given to comparative distribution of the fungi of related genera, nor to methods of collecting. Coker (1) has recently added valuable data concerning the occurrence of Saprolegniaceae in North Carolina, but he has not given a detailed description of his methods of collecting

The following account is based upon collections of fungi made during the past year, chiefly in the vicinity of Ann Arbor It does not presume to be a complete survey of the water molds in our waters. It is submitted with the hope that it may prove helpful to others who are working on the fungi of this group, as well as to point out the need of similar data from other localities It also gives added support to Von Minden's statement (7) that,

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* Paper from the Department of Botany of the University of Michigan, No. 236.

so far as is known, the fungi in this group in North America and Europe agree not only in respect to genera found, but also in respect to the distribution of these genera

The method used in making the collections was a modification of the one described by Von Minden (8) Small wire envelopes measuring about four by six inches were made of fine-meshed netting The bait was put into these, after which they were placed in position by means of a wire fastened at one end to the wire envelope and at the other end to some support near the water This use of wire netting and wire attachment was found necessary to prevent the destruction of the bait by water animals such as the *muskrat* The traps were fastened in position so that they remained near the surface of the water or merely a few inches below

It is essential to place the bait directly in the water of the lakes or streams, rather than to attempt to get infections from zoospores that happen to be present in small amounts of water brought into the laboratory During the period of infection contaminations of bacteria and protozoa are kept in check more easily out of doors in moving water, and certain difficulties in the laboratory due to the constantly increasing concentrations developing in jars indoors are likewise avoided

It is a matter of common experience to those working in this group of fungi, that Saprolegniaceae are very abundant and can be caught easily by using some form of animal bait It is also known that fungi belonging to the Leptomitaceae are not obtained on such bait, the experiences of Thaxter (5) and of Von Minden (7, 8) and others show that such fungi may be found on vegetable substrata The bait used in these collections was selected therefore with this point in mind The following materials were used for bait prune, apple, plum, pear, peach, grapes, quince, cranberry, fruits of rose, crataegus, bittersweet, solanum, wild cucumber, Indian turnip, privet, spiraea, corn, string-bean, pea pods, carrot, celery, red pepper, sweet potato and Irish potato Other collections were obtained from material found lying in the water, twigs, grass, fruit of Peltandra and root stalks of Typhus.

The following is a partial summary of the species represented in the collections

*Saprolegnia ssp* were caught on Indian turnip fruit, bittersweet, pepper, carrot, plum, grape, bean pods and pea pods

*Achlya ssp* occurred on apple, peach, grape, crataegus, solanum, sweet corn, carrot, celery, red pepper, pea pods, bean pods and twigs

*Isoachlya sp* was caught on sweet corn

*Pythiomorpha sp* made a luxuriant growth on prunes, peaches, apples, pears, grapes, quince, rose, crataegus, bittersweet, wild cucumber, fruit of Peltandra and carrot

*Pythium ssp* were caught on carrot and rose fruits

*Leptomitus sp* was caught on prune and grape

*Apodachlya sp* occurred on prune and apple

*Rhipidium ssp* were obtained from rose fruits, crataegus fruits, apple, and prune

*Blastocladia ssp* were also found on rose fruits, crataegus fruits and apple

It can be seen from the foregoing list that the bait suitable for securing Rhipidium, Leptomitus, Apodachlya and Blastocladia also served admirably for catching fungi belonging to the families Saprolegniaceae, Pythiomorphaceae and Pythiaceae In the case of the Saprolegniales, this summary is of interest chiefly because it demonstrates clearly that wide limits of adaptability in regard to the food-supply exist among the species of fungi belonging to the two genera Saprolegnia and Achlya The fact that students usually employ some form of bait having a high protein content for catching Saprolegnia and Achlya does not signify that this is the only bait that can be used successfully. It has been known for a long time, as shown by Klebs (4), Kauffman (3) and others, that certain species of Saprolegnia can be grown successfully and easily in culture in solutions rich in sugars. It is shown here that the same principles hold true in nature, although but little regard seems to have been given to this fact in connection with methods of collecting Saprolegniae and Achlyae.

*Pythiomorpha gonapodioides* Petersen, which was reported a year ago for the first time in America (2), is limited entirely to plant substrata The variety of materials used, however, was large, as the foregoing list proves In pure culture this fungus showed the same marked preference for sugars, and was grown with the greatest difficulty on beef gelatine or on house flies It was definitely identified during the past year in twenty collections and its presence was suspected in additional collections

Pythia apparently grow well both on plant and on animal substrata The list shows only the definitely identified collections Other collections presumably contained Pythia also

In the following paragraphs particular attention will be given to the fungi in the two families, Leptomitaceae and Blastocladiaceae It has been clearly demonstrated by Thaxter (5, 6) and by Von Minden (7, 8) that these forms are very specific in their use of plant substrata, but this fact does not explain why these fungi have been reported so infrequently by both European and American mycologists The Ann Arbor collections were secured from several widely separated bodies of water, which proves that these fungi are widely distributed in our waters That so little has been published concerning them may be due to certain difficulties attending the collecting It is very likely that a combination of several conditions rather than any one alone bespeaks success in securing these water molds In the light of the writer's experience the following points and their bearing on the catching of these fungi may be considered profitably.

(*a*) Selection of bait.

(*b*) Length of time the bait is exposed in the water, and the temperature of the water

(*c*) Condition of the water with reference to aeration, etc

(*a*) Since Rhipidium and Blastocladia zoöspores are positively responsive to the diffusions from plant materials, the selection of suitable bait is a matter of first consideration. The Ann Arbor collections were obtained on apple, prune and crataegus fruits, but chiefly on rose fruits. All these fruits have a firm covering and compact tissues within. Such fruits afford a distinct advantage over the softer fruits such as peaches and plums The covering of the former fruits effectively resists destruction by the mechanical action of the water in out-of-door situations, while under laboratory conditions they are superior as they remain intact for a longer period of time, which makes the handling of rough cultures a relatively easy matter Rapid disintegration of the fruit tissues brings about within the jar a high concentration of substances, which seems to act in a harmful manner on these fungi Since, as will be shown presently, it is desirable to leave the traps out of doors for a period of several weeks, it is needless to emphasize further the special importance of selecting fruits that do remain intact and at the same time allow a diffusion of substances from within

It is not easy to determine whether this resistant fruit-covering acts merely in a mechanical way as a check against a too rapid and detrimental diffusion of substances from the fruits, or whether these fruits contain some particularly favorable constituents lacking in the other kinds of bait used It may be added that re-infection of the original bait occurred on the laboratory rough cultures of apple, rose and crataegus fruits during the several months in which the laboratory rough cultures were continued, while other kinds of bait never showed signs of infection

The statements just made regarding the choice of bait for catching Rhipidia apply equally well for securing Blastocladiac In the Ann Arbor collections they were found only in fruit collections In this they agree also with the records of Blastocladiae previously reported.

(*b*) The length of time the bait is exposed in the water seems to bear a more or less direct relation to the kind of water molds caught The longer the time the better the results, relatively speaking. The traps left out of doors for nine days or less never contained anything unusual. A mycelial growth was visible on the surface of the fruit, but on close examination this was found to be a mixture of slender non-segmented hyphae often intermixed with coarse heavy-walled Achlya-like hyphae. No

Rhipidia or Blastocladiae were found at the time the cultures were brought into the laboratory, or at any subsequent time during the next three or four months

On the other hand, some of the long-time exposures were found satisfactory for securing Rhipidia The traps which were left out for three or four weeks had not only the usual overgrowths of non-segmented mycelium that might have belonged to the Saprolegniaceae, etc, but in some instances additional fungi belonging to the Leptomitaceae and Blastocladiaceae The presence of a luxuriant growth of long hyphae so characteristic of the Saprolegniaceae, which is assured by long exposure, may be instrumental in securing an infection of other fungi Rhipidia and Blastocladiae, either single plants or clusters of them, could sometimes be found at the base of some of the tufts of non-segmented hyphae It seems entirely probable that the long filaments of the rapidly growing Saprolegniae caught and held the spores of Rhipidia, etc Furthermore, it seems reasonable to suppose that fungi that develop such extensive systems of rhizoids, enlarged basal cells or thalli have in this manner an excellent means of becoming established, and that the chances of their becoming attached quickly to smooth surfaces of fruits are correspondingly less In laboratory cultures where the water is quiet, cottony clumps of these fungi do develop without this close association with other fungi

The additional time of exposure of one or two weeks does not greatly affect the amount or kind of contaminations, since they are unavoidable in rough culture Their troublesomeness depends largely upon the manner in which the cultures are handled after being brought indoors

The explanation of the differences in the results of the two foregoing series cannot be considered to be due entirely to the differences in duration of exposure The temperature relations must also be considered as being directly connected with the time-factor The short-time series of cultures was made in the early fall while the weather was still warm During September and October very little rain fell, so that the water was not changed by the disturbances due to additions of fresh supplies of water Some traps were left out for three or four weeks, which included the time from the middle of October to the early part of December During this period the water gradually became cooler, in fact, the December collections were removed from the ice It is impossible to estimate the extent of the influence of the lower temperature on the infections and subsequent development, but it is evident that freezing temperature does not kill these fungi

(*c*) The water in which the traps are placed apparently has a decided effect on the kind of fungi caught, but here again it must be clearly understood that this factor cannot and must not be regarded as the one controlling influence The nature of out-of-door collecting with the ever changing conditions makes it impossible to give anything except an approximation to actual conditions However, there are types of locations that do vary from one another sufficiently in character, and at the same time possess fairly constant conditions, so that in a general way one can predict the kind of fungi that may be obtained As many such types of habitat were chosen as the waters around Ann Arbor permitted These may be grouped into the following fresh-water lakes, running water of brooks and river, still water in pools near rivers, etc , stagnant water of semi-marshy borders of lakes * The results indicate that zoöspores of Saprolegniae, Achlyae and Pythiomorpha are present in all waters In clear rapidly moving water of brooks, river and clear beaches of lakes, these fungi appear almost to the exclusion of other forms The more quiet waters seem to favor the catching of other forms also This may be due to the fact that vegetation accumulating in or near such places offers good substrata for a greater variety of fungi, or it may mean that because of disintegration of vegetation or other processes, the correspondingly higher concentrations of substances present in solution in water that is being changed slowly favor the growth of fungi of certain genera At any rate, it was in waters of this kind that Leptomitus, Apodachlya, Blastocladiae, and Pythia were found Rhipidia were found in clear water and, with one exception, not in rapidly moving water. The Apodachlya and Leptomitus collections came from bait suspended in dirty lake water that must have contained many decomposition products from the plants growing at the marshy edge The lake bottom at this location was deep mud Pythia were collected from bait placed in clear quiet water as well as in stagnant water

The care of the material after it is brought into the laboratory determines to a great extent the usefulness of the cultures for further study Each collection was kept in rough culture in the laboratory by first washing the bait carefully in tap water and then placing it in a large covered glass capsule containing about 200 cc of sterile distilled water Contaminations of Penicillium are minimized if the bait is at all times completely covered with water. These dishes were then placed immediately in a darkened cold room with a temperature ranging from 1° to 4° C Some of them were kept successfully in a cold frame built inside a large window with a section opening to the outside by means of which the light and temperature could be regulated Here the temperature ranged throughout a wider scale, in both situations the cultures kept nicely if the water was renewed occasionally Microscopic examinations were made beginning immediately after the collections were brought indoors The sudden changes brought about by the new indoor surroundings usually result in rapid and important developments in the fungi which are aids in making preliminary studies and tentative identifications

These results are not given as a complete citation of all the fungi caught, nor of all the fungi present in these waters The making of such a survey was not the primary purpose of the collecting, hence this list includes only those genera that were very apparent in the collections, with no attempt to study all species in pure culture.

The conclusions, which are generalities, do indicate some significant time-saving points to be considered in collecting water molds, and reëmphasize the fact that in nature water molds are restricted in a greater or lesser degree in their development by external conditions

The two genera of which examples are figured in Plate I, were secured from collections on rose fruits made in March, 1925.

Figure 1 is a variety of *Blastocladia ramosa* Thaxter, for which the varietal name **luxurians**, var nov, is proposed This plant resembles that of Thaxter (6) in general habit and manner of growth It differs, however, in having sporangia which measure 160–170$\mu$ × 30–33$\mu$ and resting spores that measure 50–60 × 28–30$\mu$, both of which are considerably larger than the measurements given for *B ramosa* Since the descriptions of *B ramosa* are not complete, it is difficult to determine whether this Michigan plant is merely a variety or whether further study will show that it is a distinct species

Figure 2 is of *Rhipidium europeum* Von Minden This is the first record of this plant for America The diclinous origin of the antheridia in part separates it from *R americanum* Thaxter

In conclusion I wish to express my thanks to Dr C H Kauffman under whose direction and by whose aid this paper was made possible.

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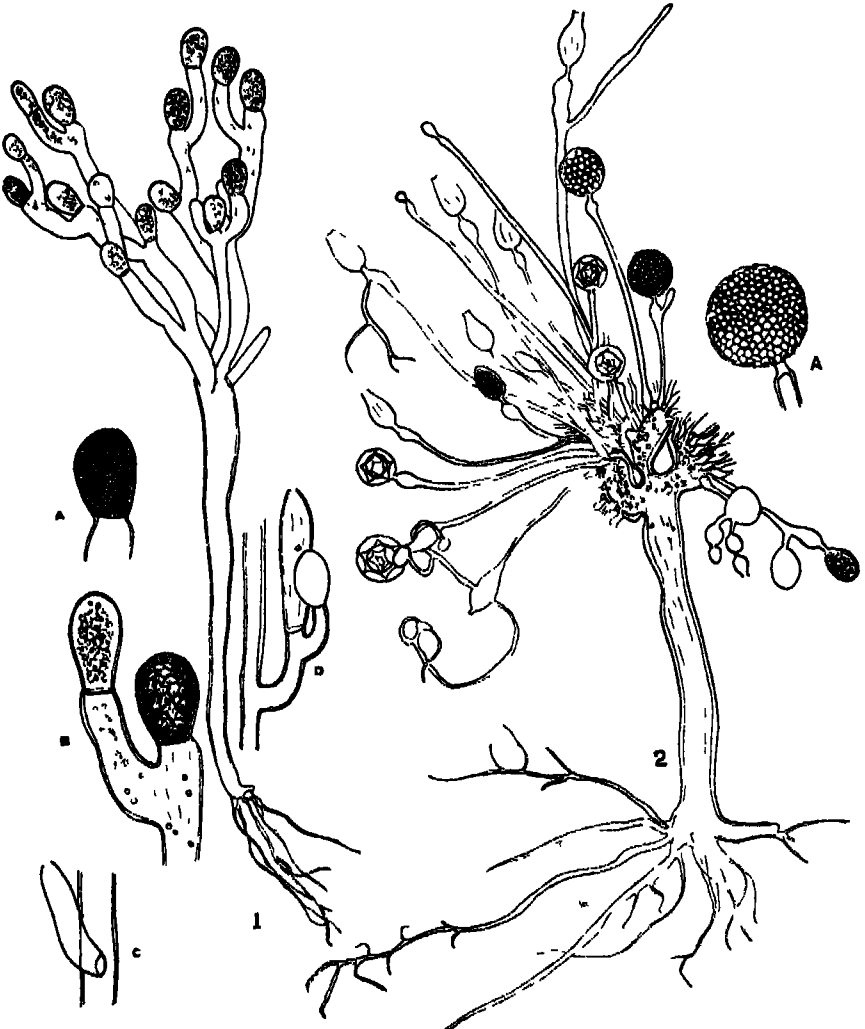
## DESCRIPTION OF PLATE I

FIG. 1 Habit sketch of *Blastocladia ramosa* var *luxurians*
a–b Different stages in the formation of resting spores
c–d. Empty sporangia showing positions on the plant

FIG 2 Habit sketch of *Rhipidium europeum*, showing enlarged basal portion with rhizoids, branches bearing sporangia, branches bearing oögonia parthenogenetically formed, branch bearing an antheridium, diclinous in origin, which is characteristic of this species
a Immature oögonium with pitted wall and showing the appearance of the protoplasm at the periphery

# PLATE I



# THE FUNGUS FLORA OF MT. HOOD, WITH SOME NEW SPECIES*

C H. KAUFFMAN

DURING the autumn of 1922, the writer, accompanied by Mr L. E. Wehmeyer, collected and studied the fungi in a small area at the western base of Mt Hood. By the advice and through the kindness of the men of the Portland Office of the United States Forest Service, accommodations were obtained at the ranch-house of Mr. and Mrs W. J. Faubian, just inside the western entrance to the Oregon National Forest, and on the first lap of the Mt Hood Highway For numerous courtesies extended by the men of the Portland Forestry Office, the writer wishes to make grateful acknowledgment

The foothills rise in abrupt ridges at this point, and represent a portion of radiating outposts of the great mountain peak visible beyond. Near by two of the valleys are well watered by the Zigzag River and the Sandy River, with their sources in the glaciers and snow-fields about twelve miles from our station. Smaller streams also abound. Some of the valleys and ridges are still covered by forests of Douglas fir, western hemlock, white fir, some scattered cedars, and in low places two species of maple and one of alder The topography and water-relations are such as to produce a variety of habitats favorable to fungi of all sorts, and as the rainy season was well started when we arrived, it was not surprising that within the single month of our stay a large mass of material came to hand. The collecting was started on September 21 and terminated October 24. The area covered was scarcely more than a two- to three-mile radius from the ranch.

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* Paper from the Department of Botany of the University of Michigan, No. 228.

In order to take complete notes and obtain the photographs, little time was left for longer excursions, and in any case, a small area well covered is likely to yield a high percentage of the possibilities of a larger area

Aside from collections of parasite fungi, our knowledge of Oregon fungi in the past has been brought about in three ways Occasionally a local amateur sent specimens to Dr Peck at Albany, Professor Atkinson at Cornell University or to Dr. Burt at St Louis In this way certain basidiomycetes and rarely species of the other groups received names, the more common fungi of interest to forest pathology were also occasionally gathered and studied by the pathologists at Washington or elsewhere Secondly, Dr. Murrill of the New York Botanical Garden, on an exploring expedition for material for the *North American Flora*, gathered a considerable number of Oregon fungi which he later described and named. The latest additions to the flora of the State were compiled by Zeller (21) and it is to be hoped that this author will find opportunity to continue his research in this, an almost unstudied part of our country

Two mycological features impress an eastern mycologist when he enters the Pacific states west of the Cascade Range. In the first place, many species, if one is at all familiar with northern European plants, are found to be old Friesian species In the second place he is astonished — nay, somewhat alarmed at his own ignorance — to find so many that appear to be undescribed. Such meager information as we have of that fatal trip to the state of Washington, by the late Professor Atkinson, indicates that he, too, was impressed by the multitude of new forms, and his anxiety to waste no second in this fascinating country is believed to have lured him to overtax his strength and to overlook the signs of physical exhaustion.

It has been the author's policy to refrain as much as possible from the business of describing species. During 1915, with two assistants, the writer spent two months in the mountains of Washington, and obtained a large number of (new) species. After ten years of contemplation about a considerable number of forms then seen, and in frequent cases again collected in 1922, it seemed highly desirable in the interests of the future of Pacific Coast mycology, that these species should be described The more outstanding forms have, therefore, been selected and are given below. In order to keep this paper within bounds, only the basidiomycetes are included, if possible the other groups will be presented later

All material and type-specimens are deposited in the Herbarium of the University of Michigan

## BASIDIOMYCETES

## *AGARICALES*

### THELEPHORACEAE

HYMENOCHAETE BADIO-FERRUGINEA (Mart ) Lév. — On dead stems of *Vaccinium parviflorum.*

HYMENOCHAETE FULIGINOSA (Pers ) Bres — On decorticated wood of some frondose tree

HYMENOCHAETE SPRETA Pk. — On decayed wood Only the first setigerous layer is present.

SEBACINA DENDROIDEA (Pk. & Cke.) Lloyd — On *Fomes applanatus.*

STEREUM HIRSUTUM Fr — On dead branches of *Alnus oregona.*

THELEPHORA CARYOPHYLLEA Fr. — On decayed wood remnants and humus.

THELEPHORA INTYBACEA Fr — On debris on the ground in conifer woods

### HYDNACEAE

CALDESIELLA CRINALIS (Fr ) Bourd. & Galatz. — On very rotten wood.

HYDNUM AURISCALPIUM Fr. — On cones of Douglas fir Frequent.

HYDNUM CAPUT-URSAE Fr. — On alder log.

HYDNUM COMPLICATUM Banker. — On debris under conifers The odor is definitely and agreeably aromatic when the fresh plants are bruised. Young or growing plants are white on and near the margin, "cinnamon-rufous" (R [1]) or darker on disk, all parts becoming dark-brown to reddish-blackish-brown after bruising or in age, so that the colors vary considerably in different plants The texture is hard and tough in the interior portions The spores are as given by Banker (3)

HYDNUM GRAVEOLENS Delast var — The same species as that reported from Colorado by Kauffman (13, p 116)

HYDNUM FULIGINEO-VIOLACEUM Kalchbr Bres — This is without doubt the species described and figured by Bresadola (6)

MUCRONELLA AGGREGATA Fr — On bark of decaying birch sticks Spores short, ellipsoid, 4–5 × 3 μ, smooth, hyaline

PHLEBIA CINNABARINA Schw — On decayed wood

PHLEBIA RADIATA Fr. — On decayed wood

## CLAVARIACEAE

CLAVARIA CINEREA Fr

CLAVARIA DENSA Pk

CLAVARIA FLAVULOIDES Burt

CLAVARIA FUSIFORMIS Fr

CLAVARIA LIGULA Fr

**Clavaria nebulosoides,** sp nov — FRUIT BODY simple, fleshy, cylindrical, stipitate, fertile portion 3-5 cm long, 1 5–2 mm thick, "wood brown" to "fawn color." STIPE slender 1 5–3 cm long, minutely pruinose SPORES oblong, 5–6 × 2 5 μ, hyaline, smooth, cystidia 65–70 × 7–12 μ, fairly abundant, hyaline, thin-walled, lanceolate, pedicel long and slender, basidia 4-spored, 30 × 5 μ.

On mosses in conifer forest Mt Hood, Oregon October 15. Collected by L E Wehmeyer.

Distinguished by its habit, color and the presence of cystidia

LACHNOCLADIUM ORNATIPES (Pk ) Burt. (See Plate II, Fig. 1.) — The synonymy of this species is given by Burt (8, p 66). Both because the descriptions have been meager, and because Burt finds the spores of the type-specimens quite a little smaller than in our specimens and as given by Peck, I include here a more complete description FRUIT BODY 4–8 cm tall, dichotomously branched, with few to several main branches FERTILE BRANCHES occupying mostly only the upper half of the plant, subfleshy, smooth, "avellaneous" (R ), or paler towards the tips, dilated and compressed-subrugose upwards, terminal branches attenuated-acute, with pointed apices in two's or three's STEM and sterile branches 3–4 cm long, 3 8 mm thick, rather tough, clothed by a strigose-hairy thick covering, "army-brown" (R ) to "avellaneous," subterete or compressed upwards, context solid, subspongy, similar to, but of a deeper color than, the hymenium SPORES spherical, with abrupt slender apiculus, hyaline, smooth, granular within, 9–10 μ (11 5 with apiculus), basidia 1–2-spored, rarely 3-spored, on long subcurved sterigmata, cystidia none ODOR none, taste mild or slowly somewhat bitter

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[1] "R." as used in this paper refers to Ridgway's *Color Standards and Nomenclature*, 1912

Growing on mossy humus or very rotten debris under conifers October

**Pistillaria fusiformis,** sp nov (See Plate II, Fig 2 ) — FRUIT BODY fleshy, white, subfusiform-acuminate, 3–5 mm. tall, somewhat curved, fertile portion subcompressed, sometimes furrowed on the flattened side STEM slender, scarcely more than 1 mm long, terete, minutely hairy, white, sclerotium none SPORES oval-elliptical to subglobose, 7 5 × 6 μ, hyaline, smooth, basidia 45 × 8–9 μ, 2- to 3-spored with prominent, slender sterigmata, cystidia none

On decayed coniferous wood. Gregarious Mt Hood, Oregon October 7. Collected by L E Wehmeyer.

The body is entirely fleshy, spongy and homogeneous within The general shape and appearance are like that shown by Patouillard (18) for *P rosellae* var. *ramosa*, Fig 53, but otherwise different.

TYPHULA PHACORRHIZA Fr. — In alder thickets

**Typhula cystidiophora,** sp nov — FRUIT BODY simple, fertile portion cylindrical, 2–5 cm long, 1–1.5 mm thick, obtuse, subpruinose or almost glabrous under a lens, white or tinted pale yellowish; context soft, fleshy, subfragile STEM filiform, 2-2.5

cm. long, .5–1 mm. in diameter, tough, concolor, minutely hirsute **Spores** narrowly elliptic-subovate, guttate, smooth, subhyaline and tinged ochraceous, 5–6.5 × 2.5–3 μ, basidia 4-spored, slender, 45–50 × 4–5 μ, cystidia abundant, lanceolate to subcylindric below, subacute to subcapitate above, hyaline, thin-walled, pedicel slender, 50–75 × 8–12 μ. **Sclerotium** fuscous, depressed-subglobose, 4–6 mm. diameter

On moist soil among mosses in conifer forest Subgregarious Mt. Hood, Oregon. October 12. Collected by C H Kauffman.

This differs from *T gyrans* Fr and other related species in the presence of cystidia throughout the hymenium and by the elongated fertile portion of the plant

**Typhula mucor** Pat — **Fruit Body** white, 1–1 5 cm. tall, fertile portion oblong, 2–3 mm. long, 2–3 mm thick, glabrous **Stem** very slender, filiform, 1–.3 mm thick, glabrous, composed of parallel hyaline hyphae, 2.5 μ diam **Sclerotium** minute, subglobose, dark brown. **Spores** subcylindric, hyaline, smooth, 7–9 5 × 2 5–3 μ, cystidia none, basidia 4-spored, 24–26 × 4–5 μ.

On decaying leaves of frondose trees October.

This minute species is so close to that figured and described by Patouillard (18) that it must be considered at most merely a taller form

## POLYPORACEAE

**Fomes igniarius** Fr — On trunks of alder and willow. This is the form usually found on poplar.

**Merulius fugax** Fr. — On conifer wood.

**Merulius hexagonoides** Burt. — On decayed wood and bark Fertile portion when fresh "tawny" to "Saccardo-umber" (R ), sterile margin white.

**Merulius pinastri** (Fr ) Burt. — On rotten wood in conifer forest

**Merulius tremellosus** Fr. — On decayed sticks and branches.

**Polyporus aurantiacus** Pk. — On hemlock log

**Polyporus elegans** Fr. — On dead branches.

**Polyporus cinnamomeus** Fr. — On sandy ground.

**Polyporus fragilis** Fr. — On logs of Douglas fir.

**Polyporus galactinus** Fr. — On very rotten wood, among alder and maple

**Polyporus guttulatus** Pk — On conifer log

**Polyporus (Ganoderma) oregonensis** Murrill — On conifer log.

**Polyporus hirtus** Fr — On the base of a dead Douglas fir stub

**Polyporus perennis** Fr — On the ground, conifer forest.

**Polyporus picipes** Fr — On conifer logs.

**Polyporus radiatus** Fr — On dead alder trunk

**Polyporus bensoinus** Fr.–Lloyd. — On decayed log of Douglas fir

**Polyporus Schweinitzii** Fr. — On roots of Douglas fir.

**Polyporus sulphureus** Fr — On Douglas fir logs

**Polystictus hirsutus** Fr. — On alder branches

**Poria ferruginosa** Fr — On fallen branches of *Acer circinatum* and *Acer macrophyllum*

**Poria medulla-panis** Fr. var. **colorata** Overh. — On decayed wood of Douglas fir

**Poria mollusca** Fr — On much decayed wood, probably of frondose trees

**Trametes carnea** Nees — On Douglas fir logs

## BOLETACEAE

**Boletinus pictus** Pk.

**Boletus granulatus** Fr. — Whitish form

**Boletus luteus** Fr.

**Boletus subtomentosus** Fr

**Boletus tomentosus** Kauff

**Boletus mirabilis** Murrill. (See Plate III) — Pileus fleshy, firm, 5–12 cm. broad, "maroon" (R) colored, dry, densely velvety tomentose, with an incurved, sterile, narrow, membranous margin, flesh compact, pale yellowish, becoming reddish-tinted or shot through with red streaks when cut or bruised. Tubes "citron-yellow" (R) when young, becoming "olive-yellow" when bruised or in age, 10–15 mm long, adnate, narrowly depressed around the stem, not stuffed, regular, mouths angular, 1–1.5 per millimeter, dissepiments thick, entire. **Stem** stout and often rather long, 10–12(15) cm. long, tapering upwards from the clavate base, very abruptly short-pointed at base, subviscid, pale yellow and more or less reticulate at apex, conspicuously and longitudinally streaked by "maroon" color, white at the very base, 1–2.5 cm. thick above, 2–5.5 cm. thick below, solid, flesh yellowish upwards, at length tinged with reddish, whitish downwards. **Spores** 18–24(27) × 6–9 μ, ventricose-fusiform, smooth and even, yellowish-ochraceous, exospore tinted reddish, basidia 4-spored, 48–50 × 12–15 μ, cystidia fairly abundant, ventricose-lanceolate, hyaline, 90 × 15–24 μ, obtuse at apex, pedicel slender. **Odor** and taste mild.

On the ground in fir forests. Mt. Hood, Oregon. September 28 and 30. Collected by L. E. Wehmeyer.

Only *B. russellii* and *B. Betula* have spores approaching in size those of this species. By the stem characters, however, its relationship is elsewhere. In the fresh condition the stem is covered by a delicate hoariness, of cobweb-like texture, which is responsible for the slight viscidity in wet weather, and which is continuous at first with the incurved delicate membranous margin of the pileus. Occasionally the tubes verge into the reticulations at the apex of the stem, so as to appear slightly decurrent. The flesh and tubes do not turn blue when wounded. Under the arrangement of Dr. Peck, the species inclines towards the Calopodes, although the stems in the specimens seen were reticulate only at the apex. It departs from the characters assumed for the Edules in the tubes not being at first stuffed, although it approaches such large species as *B. eximius* and *B. edulis* in color and size. Murrill (*Mycologia*, 4: 98, 217) named and described this species, but evidently under other weather conditions, as its pileus is said to be bay color and its surface composed of floccose, but rigid, conic persistent papillae.

## AGARICACEAE

**Amanita junquillea** Quél. — This is reported from North Carolina by Beardslee (4), also as *A. gemmata* (Fr.) Gill. by Coker (9). I have collected the North Carolina plant a number of times in Virginia and Maryland The collections from that region have spores which tend to average below 9 μ long, while in the European plant the spores are given 10–12 × 7–8 μ by Ricken (20) and 11–13 × 7–9 μ by Boudier (5) In the West, a very similar species is found, with the spores measuring 10–12 × 7–8 μ The latter I believe to be the genuine *A junquillea* as described in Europe I do not feel sure that the plant from the Eastern United States can properly be referred here, although it is certainly close to *A junquillea* in most of its characters One can of course find occasional longer spores in the Eastern plant, but to record such merely confuses the record In this connection, I should like to reiterate (12, p 617) that *A russuloides* Pk is a different and distinct species, and should not be included in any synonymy under *A junquillea* or *A gemmata* Some of my collections in the East are very probably genuine *A gemmata* (Fr ) Gill

AMANITA MUSCARIA Fr — The scarlet-capped form of Europe. Frequent

**Amanita silvicola** sp nov (See Plate IV ) — PILEUS 6–10(12) cm broad, at first broadly convex, then plane to subrepand, *white*, subviscid, when young covered by a soft, floccose, continuous white universal veil which later is irregularly disposed in flat patches or masses, not warty, margin persistently incurved, even, and at maturity crenate from the appendiculate veil-remnants, flesh abruptly thin on margin, scarcely over a centimetor thick near stem, soft GILLS reaching stem, *free except by decurrent lines, or obscurely and very narrowly adnate*, white, crowded, medium broad, 6–7 mm , edge distinctly flocculose STEM 6–10 cm long, at first with the pileus seated on a subnapiform bulb and surrounded by the smooth, floccose universal veil, at length elongated and subequal, 15–25 mm thick, bulb up to 3 cm thick, white, surface at maturity covered by obscure floccose-silky remains of the veil, at times terminating in a narrow, quickly evanescent floccose annulus, bulb edged by a circular indistinct line which is the edge of the separated veil, solid, rather compact and firm. ODOR and taste none SPORES 9–10(12) × 5–5.5(6) μ, elliptical, smooth, white, obliquely apiculate, basidia clavate, 48–50 × 8–9 μ. 4-spored, sterile cells on edge of gills large, globose-pyriform, 24–30 μ wide.

In thick forests of hemlock and cedar Mt. Hood, Oregon September 30 Collected by C H Kauffman

The whole plant is pure white The volva, although about a millimeter thick on the young pileus, because of its soft texture leaves only thin remnants on the stem, it is circumscissile Because of the napiform bulb, one might think of it as belonging to the *A. solitaria* group. However, the universal veil is very different from those of that group; the bulb is not rooting, the pileus is without warty scales, and the spores are distinctly narrower than those of *A solitaria*, while the absence of any odor separates it from *A. chlorinosma*

AMANITA TOMENTELLA Kromb. — In forests of hemlock and cedar See Kauffman (12, p. 607).

AMANITOPSIS STRANGULATA Fr. — On mosses in hemlock forest. Stout and massive specimens

ARMILLARIA ALBOLANARIPES Atk — In hemlock and fir forest

ARMILLARIA VISCIDIPES Pk — For a full discussion of this species see Kauffman (14, p 62) It may reach a huge size, pileus up to 20 cm. broad, stem up to 12 cm long and 4 cm. thick at apex, gills up to 15–18 mm broad

ARMILLARIA CINNABARINA (Fr ) Kauff. — (See 14, p. 60.)

CANTHERELLUS AURANTIACUS Fr.

CANTHERELLUS CIBARIUS Fr.

CANTHERELLUS FLOCCOSUS Schw.

CANTHERELLUS INFUNDIBULIFORMIS Fr.

CANTHERELLUS MULTIPLEX Underw (See Plate V.) — I have collected and studied this curious species several times. It occurs in the Rocky Mountains of Wyoming and Colorado, in the Olympic Mountains of Washington and in the Cascade Mountains of Washington and Oregon, including Mt. Hood. It was originally collected at Mt. Desert, Maine It may be looked for in coniferous forests of the higher latitudes of North America or in the mountains southward Murrill (17) erected the genus Polyzellus for it. It is, however, only a very extreme growth-condition of *C. clavatus*, and typical individuals of the latter species are to be found with the — often abundant — "multiplex" plants. The photograph is of the intermediate type. E. T. Harper in *Mycologia*, Volume 5, Plate 94, has illustrated what is undoubtedly the same plant, and properly referred it to *C. clavatus*.

CANTHERELLUS PRUINOSUS Pk. — On debris under coniferous trees. Although this determination may be open to question, yet in the absence of any recorded microscopic characters for Peck's species, it seems to me more than probable that we have here the species so briefly described by him (*N. Y. State Mus. Rep.*, 28: 51. 1876). Patouillard (18), in *Tabulae Analyticae*, figured (No. 651) a species from Guinea, South America, of which the slender specimens there shown well illustrate the size and shape of our plant. That species, however, has different spores and grows in the tropics. The western plant is white throughout, 2.5 cm. tall, shaped like the slightly curved horn of a cow, flaring slightly at the top, depressed-subinfundibuliform, and externally with narrow, longitudinal ridges, a few of these may be forked. The spores are spherical, hyaline and smooth, the basidia are 4-spored, elongated, subclavate 90–100 × 4 μ.

COLLYBIA ACERVATA Fr.

COLLYBIA ALBIFLAVIDA (Pk.) Kauff. var. MONTANUM Kauff.

COLLYBIA ALBIPILATA Pk. — On cones of Douglas fir. Common. This is without doubt Peck's species. However, it is very likely to turn out to be only a somewhat smaller American form of one of the European species. The idea of the spore-size for *C. esculenta* and *C. conigena* as given by Bresadola (6), 6–8 × 3–4 μ, has not been followed by later European authors, e.g. Ricken (20), Rea (19) and Lange (16). The spores of my collection measure 3.5–4 × 2 μ, and the cystidia are "fusoid-ventricose," capitate. In this latter respect it agrees with Bresadola's conception of *C. esculenta*. The pileus, however, is "pale cinnamon-pink" when fresh, becoming "pinkish-cinnamon" in age, and is *pruinose;* this pruinosity is due to erect cystidia-like cells projecting from the corticate surface layer of the pileus. All this is distinctly a character of the American species. The

European species, *C. esculenta* and *C. conigena*, have entirely glabrous caps. Lange (16) recognizes only *C. tenecella* and *C. conigena*, and gives the larger spore-size to the former, the small spore-size to the latter. Evidently Murrill is right in saying that no typical material of these European species has as yet turned up in America. *C. albipilata* occurs on various cones, although usually reported only on pine cones. The other similar thing in the United States is *C. conigenoides* Ell. on magnolia cones. See Kauffman (11).

COLLYBIA CONFLUENS Fr.

**Collybia cylindrospora**, sp. nov. — PILEUS subpliant, 4–6(7) cm. broad, convex-expanded and soon irregularly repand, obsoletely umbonate or obtuse, glabrous, even, moist, with a tough cuticle, dull "antimony yellow" (R.), disk tinged "cinnamon rufous", flesh of equal thickness, 1–1.5 mm., white. GILLS broadly adnate, rather broad, narrowed in front to a point and not reaching the edge of the pileus, subarid, slightly tough, close, occasionally interveined, whitish. STEM 8–10(12) cm. long, 4–6(8) mm. thick, irregularly twisted, striate to furrowed-compressed, hollow, glabrous, "cinnamon" (R.), sometimes darker downwards, subrooting at base. ODOR and taste slightly disagreeable, earthy. SPORES subcylindric, smooth, hyaline, 5–6 × 1.5–2 μ, cystidia none; sterile cells on edge of gills filiform, about 2 μ wide, basidia 4-spored, 30 × 5–6 μ.

On debris and very rotten wood in conifer forest. Mt. Hood, Oregon. October 5. Collected by C. H. Kauffman.

It is distinguished from its near relatives, like *C. fusipes*, *C. lancipes* and *C. distorta*, especially by its narrow, cylindrical spores. The stems are sometimes connate part way. Its general appearance is like that of *C. rugulosiceps*.

COLLYBIA PLATYPHYLLA Fr.

COLLYBIA PROLIXA Fr.-Ricken

COLLYBIA PROTRACTA Fr.-Ricken

**Collybia rugulosiceps**, sp. nov. (See Plate VI.) — PILEUS 3–5 cm. broad, very pliant, convex-plane, with a distinct obtuse umbo, at length depressed around umbo, moist, hygrophanous, glabrous, radiately and finely rugulose to umbo, "cinnamon drab" to "avellaneous" (R), umbo "sayal-brown" (R), becoming somewhat paler when dry, margin thin, substriate, splitting radially in age, acute, soon spreading, flesh thin, concolor Gills narrowly adnate, soon sinuate and decurrent, rather narrow, and narrowed in front to a point, 3–6 mm broad, whitish with indistinct gray tints, close to subdistant, here and there intervenose Stem 4–8(10) cm long, 3–5 mm thick, slender, equal, abruptly dilated at apex, sometimes twisted, hollow, terete or compressed-furrowed, glabrous and naked, entirely even, tough-cartilaginous, almost horny, "wood-brown" to "avellaneous" or darker, white-substrigose at the very base Odor and taste entirely lacking Spores broadly elliptical, smooth, hyaline, 8–9(12) × 5–7(8) $\mu$, variable, basidia 4-spored, 32–34 × 5–6 $\mu$, cystidia none, sterile cells on edge of gills oval, short and indistinct

Always on decayed logs or wood remains of conifers, cespitose or subcespitose Common Mt Hood, Oregon October 3 Collected by C H Kauffman

It belongs to the section Tephrophanae, although neither the hygrophanous character, nor the gray tints of the gills are strongly marked In its relationship, it verges towards *C lancipes* Fr., but the stem is not atriate and the gills are not broad From *C rugosiceps* Atk and *C. subrugosa* Murrill it differs in the character of its gills and spores as well as in its colors and habitat It has much the appearance of some of the *Tricholoma melanaleuca* group, but lacks cystidia, has different colors and the stem is truly cartilaginous The surface layer of the pileus is corticate, composed of one or two series of globose-pyriform, brown cells

**Claudopus byssissedus** Fr.
**Clitocybe amara** Fr.
**Clitocybe atrialba** Murrill
**Clitocybe clavipes** Pk.
**Clitocybe decora** Fr.
**Clitocybe ectypoides** Pk.
**Clitocybe gallinacea** Fr.
**Clitocybe laccata** Fr.
**Clitocybe media** Pk
**Clitocybe nebularis** Fr
**Clitocybe ochropurpurea** Berk.
**Clitocybe pithyophilus** Fr
**Clitocybe suaveolens** Fr
**Clitopilus novaboracensis** Pk
**Clitopilus woodianus** Pk.

Coprinus atramentarius Fr.

Coprinus fimetarius var. macrorhiza Fr

Cortinarius amarus Fr.

Cortinarius anomalus Fr.

Cortinarius badius Pk

Cortinarius bulbosus Fr.

**Cortinarius clandestinus,** sp nov. (Dermocybe). (In press, *North American Flora,* Vol. 10)

Cortinarius dilutus Fr.

Cortinarius evernius Fr.

Cortinarius fucatophyllus Lasch–Ricken

Cortinarius laniger Fr.

Cortinarius longipes Pk.

**Cortinarius montanus,** sp nov (Bulbopodium) (In press, *North American Flora,* Vol 10)

Cortinarius mucifluus Fr

Cortinarius obtusus Fr

Cortinarius paleaceus Fr.

**Cortinarius pyriodorus,** sp nov (Inoloma) (In press, *North American Flora,* Vol 10)

Cortinarius renidens Fr.

Cortinarius rigidus Fr

Cortinarius saturninus Fr

Cortinarius subsimilis Fr – Ricken

Cortinarius violaceus Fr

Cortinarius whitei Pk

Dictyolus retirugis (Fr ) Quél — On species of Hypnum mosses Spores elliptical, smooth, hyaline, 7–8 × 4–4 5 μ, cystidia none; basidia clavate, 4-spored, 40 × 6 μ The hymenial surface may be provided with radiating vein-like ridges which do not reach the margin of the pileus, or it may be even without any sign of gill development Fruit Body 4–6 mm wide, sessile, convex-subreniform to orbicular, surface of pileus "cartridge-buff" (R.) when fresh, tinged grayish on drying, indistinctly pruinose under a lens Although departing slightly from the species to which it is here referred, it seems too close to it to be considered a distinct species

**Eccilia bispora,** sp nov. — Pileus 1-2 5 cm broad, convex-depressed or umbilicate, sometimes subumbonate, rather elastic but somewhat brittle, glabrous, with a separable gelatinous pellicle and slightly viscid in wet weather, "avellaneous" (R ), indistinctly striatulate on margin, which is at first incurved rather than decurved; flesh concolor, rather thin, tapering to margin. Gills broadly adnate, sometimes with decurrent tooth, broad, close to almost subdistant, becoming deep flesh-color, edge entire Stem 4–5(8) cm. long, 3–6(8) mm. thick, equal or tapering downwards, often compressed-furrowed, dilated at apex, cartilaginous, brittle, almost glassy, hyaline-white, hollow, even, white-mycelioid at base Odor and taste rancid-farinaceous. Spores obtusely angular, broadly ellipsoid, 10–12 × 8–10 μ, deep flesh-color under the microscope, basidia 2-spored 45 × 8–9 μ, hymenium with abundant, sterile, cystidia-like cells which are acutely pointed, but scarcely project beyond the basidia, true cystidia none.

On wood debris. Mt. Hood, Oregon. October 5 Collected by C H Kauffman

Nearly all of the cartilaginous-stemmed species of Leptonia, Nolanea and Eccilia have slender and equal stems In this species the stem has a tendency to be irregularly undulate and subcompressed, in the larger specimens quite thick, while in contrast to its length, the caps are narrow. The pellicle of the pileus, the stem features and the microscopic characters set it off from other species The slight tooth of the gills may induce one to look for it under Leptonia, and the stem character at first sight suggests an Entoloma or Clitopilus The two-spored basidia and other microscopic characters were a constant feature in two different collections

Entoloma nidorosum Fr

Entoloma nitidum Quél.

Entoloma speculum Fr.

Flammula astragalina Fr.

Flammula liquiritiae Fr.

Flammula sapinea Fr.

Flammula spumosa Fr.

Galera hypnorum Fr

**Galera martipes**, sp nov—Pileus 5–8 mm. high and wide, conical, obtuse, hygrophanous "clay color" (R.) and long-striate (moist), "pinkish buff," even and atomate (dry); flesh very thin, concolorous. Gills adnate, ascending, ventricose but rather narrow, subdistant. Stem 8–10 cm. long, 1 mm. thick, slender, equal, "mars-brown" (R.), clay-color at apex, minutely pruinose throughout, pruinosity due to minute, spreading hairs, fistulose, mars-brown within, cartilaginous, flexuous Odor and taste none. Spores oval-subventricose, smooth, ochraceous, 8–9 × 4–5 μ; cystidia abundant on edge of gills and near, scattered on sides, rounded-ventricose above the slender pedicel, neck abruptly narrow, lance-shaped to aciculate, hyaline, 60–75 × 12–18 μ.

Attached to mosses and decayed needles, in forest of hemlock and Douglas fir. Mt. Hood, Oregon, September 2 Collected by C H Kauffman.

The pileus is homogeneous in structure, not corticate The species is closely related to *G hypnorum*, but differs constantly in its longer and pruinose stems, smaller spores and the character and distribution of the cystidia See Atkinson (2) for relationships of the species of Galera

**Gomphidius ochraceus**, sp nov (*Mycologia*, 17 119 1925)

**Gomphidius subroseus**, sp nov (*Op cit*, 17 120 1925)

GOMPHIDIUS TOMENTOSUS Murrill (*Op cit*, 17 124 1925)

HEBELOMA ELATUM Fr
HEBELOMA PUNCTATUM Fr
HYGROPHORUS CERACEUS Fr.
HYGROPHORUS COCCINEUS Fr
HYGROPHORUS CONICUS Fr
HYGROPHORUS PARVULUS Pk

**Hygrophorus mollis** (B & Br ), comb nov — PILEUS 5-12 mm broad, at first discoid, then broadly convex, obtuse, moist, "mikado orange" (R ), decorated by fine, pointed, concolorous fascicles of fibrils which suggest a minutely echinulate appearance, margin at first incurved, even, flesh relatively thick, thinner on margin, concolor. GILLS adnate, rather narrow, of equal width, subdistant, waxy, "light orange-yellow" STEM 1-2 5 cm long, 1.5-2 mm. thick, "light orange-yellow" (R ), equal, glabrous, hollow, toughish, concolorous within, apex naked but attached at base by delicate radiating, pure white hairs, cortina none. SPORES elliptical, smooth, hyaline, 8-9 × 4-4 5(5), basidia 48-50 × 7-8 $\mu$, cystidia none, gill-trama of interwoven hyphae, trama of pileus floccose, homogeneous, composed of concolorous hyphae, sterile cells inconspicuous.

On a very decayed log under Douglas fir. Subcespitose. Mt Hood, Oregon. October 16 Collected by L. E Wehmeyer.

This species departs in such minor particulars from the European form which goes under the name of *H. turundus* var *mollis*, that it seems clearly to be the same I have here raised the variety to specific rank on microscopical grounds The whole plant has a waxy lustre. No cortina was visible even in the youngest specimen. The decoration of the cap gives a white sheen when reflecting the light It belongs to the subgenus Camarophyllus.

**Hygrophorus fimbriatophyllus**, sp nov — Pileus 2–3 cm broad, at first oval-hemispherical then broadly convex, obtuse, uniformly "apricot-yellow" (R ), fibrillose-floccose or broken into soft and small scales, margin even, at first incurved and silky from the cortina, flesh moist, concolor, 2 mm thick near stem, narrowed to the margin of the pileus Gills broadly adnate or at length spuriously subdecurrent, rather narrow, 2–4 mm , "apricot-yellow," waxy, edge concolorous and fimbriate Stem 4–7 cm long tapering upwards, 2–3 5 mm. thick at apex, 3–6 mm. at base, concolor, even, flexuous, at first silky-fibrillose, glabrescent Odor and taste none Spores subglobose to broadly elliptical, smooth, hyaline, 7–8(9) × 6–7 μ, cystidia none, sterile cells on the edge of the gills prominent, cylindrical, obtuse, 100–120 × 4–5 μ, hyaline, gill-trama interwoven

On very rotten wood in conifer forest. Mt Hood, Oregon October 13 Collected by L. E Wehmeyer

The pileus although fleshy is thin and somewhat pliant, but the waxy gills preclude the genus Clitocybe The young plant is surrounded by the continuation of the pileus covering, thus indicating a universal veil. *H intermedium* Pass -Ricken has a similar covering Our plant belongs to the subgenus Camarophyllus

**Hygrophorus multifolius**, sp nov (See Plate VII ) — Pileus 1.5–4 cm broad, pliant, at first broadly convex and discoid, at length plane to depressed with a small umbo and a decurved margin, *viscous*, *with a thin, separable pellicle, soon dry and subtomentose*, putty-colored to "drab" (R ), margin at first incurved and persistently translucent-striatulate, incurved portion subtomentose; flesh rather thin, 1.5 mm near stem, tapering gradually to margin, concolor, fading. Gills adnate-subdecurrent, at length decurrent by elevation of cap-margin, narrow, 3–4 mm , almost linear, close or subcrowded, "echru-drab" (R ) or paler, waxy, edge entire. Stem 3–5 cm long, 2–3.5 mm. thick, equal, terete or compressed, hollow, slightly viscid when fresh from the thin hyaline evanescent universal veil, sometimes white-silky or lacerate-silky in upper portion, "light drab" within and without, fading, toughish Odor strongly farinaceous, taste similar. Spores suboblong, smooth, hyaline, 6-6 5(7) × 3-3.5 μ, cystidia none, basidia 4-spored 45-50 × 4 5 μ, sterile cells on edge of gills inconspicuous, gill-trama with parallel-diverging hyphae, those in axis parallel.

On deep moss and on needle beds in hemlock, cedar and fir forest. Gregarious to subcespitose Mt Hood, Oregon October 1 to 15. Collected by L E Wehmeyer

This species has much the appearance and habit of Clitocybe It is, however, a true Hygrophorus, as shown by its viscid veil and by its gill structure. It belongs to the subgenus Limacium. Its near relatives all have distant gills When artificially dried after collecting, those growing in wet weather dry dark while those already wind-dried retain their colors

Hypholoma fasciculare Fr

Hypholoma olivaespora Ellis — See *H vinosum* Kauff. (12, p 261), which is a synonym.

**Hypholoma canoceps**, sp nov — Pileus 1-2 cm broad, about 1 cm. high, fragile, conical-campanulate to broadly conical, hygrophanous, "cinnamon-drab" (R) when moist, but this ground-color almost hidden except on umbo by an appressed radially disposed, white-villose innate silkiness, slowly fading, at length subglabrescent, margin at first straight, appressed silky, not striate, flesh thin, concolor Gills adnate, rounded behind, seceding, narrow, 2 mm., crowded, "cinnamon-drab," white-flocculose on edge Stem 4-6 cm long, 2 5-3 mm thick, equal, white, fragile, straight or curved at base, hollow, even, at first covered by a rather persistent white-silky floccosity, at length glabrescent, whitish within, rather cartilaginous Odor and taste none. Spores elliptic-oblong, subobtuse, smooth, purplish-brown, 8-9 5 × 3 5-4 5 μ, cystidia on sides of gills are lacking; sterile cells on edge short cystidia-like, ventricose-subglobose above pedicel, with abruptly narrowed, cylindric neck, thin-walled, hyaline, 40-50 × 8-12 μ, neck 4 μ diameter.

On very rotten pieces of wood mixed with black alluvial moist soil in conifer forest. Mt. Hood, Oregon. October 14. Collected by C. H. Kauffman.

This species has two characters which might lead one to place it in the genus Psathyra, viz the cartilaginous stem and straight margin of the young pileus The innate character of the pileus covering which represents a universal veil is, however, a Hypholoma character The universal veil in the indusiate Psathyras is detersile and usually only scattered loose flecks of it are found on the young pileus. This species is to be placed in the section of Hypholoma to which *H velutinum* and *H melanthinum* belong, in spite of the fact that the spore characters are different from those species It forms a connecting link between Hypholoma and Psathyra.

**Hypholoma tsugaecola**, sp nov. (See Plate VIII.) — PILEUS 3–7 cm broad, thin and pliant, convex then subexpanded-discoid, finally depressed on disk, and margin elevated, *subviscid*, with a separable subgelatinous pellicle, *hygrophanous*, "buckthorn brown" to "ochraceous-tawny" (R ) when moist, "yellow ochre" to "antimony-yellow" when dry, *glabrous*, but margin narrowly appendiculate from the veil, margin at first incurved, very thin and acute, pellucid-long-striatulate, flesh about 1 mm thick, thicker on disk, concolor, fading GILLS adnate-subdecurrent, close, narrow, almost linear, 5–7 mm , soon "ochraceous-tawny" (R.) with a darker sheen by reflected light, edge entire. STEM curved-ascending, 5–8 cm long, subequal, 5–8(10) mm thick, apex conspicuously dilated in the region of gill-attachment, "*snuff-brown*" (R.) within and without, surface at first with scattered, scurf-like detersile scales up to the obsolete annulus, then longitudinally fibrillose, rigid, fibrous with subcartilaginous cortex, solid below, firmly stuffed, finally hollow at the apex ODOR none; taste bitterish. SPORES 6–7.5 × 4–4 5 (5) μ, short ellipsoid, smooth, purplish-brown under the microscope, dark purplish in mass; cystidia none, sterile cells indistinct; basidia 4-spored, 32 × 4–5 μ

Cespitose on dead hemlock stub Mt Hood, Oregon. October 9. Collected by C. H. Kauffman.

There are relatively few viscid or pelliculose species of Hypholoma, two rare British species have been described. *H. incomptum* Massee is similar to ours, but differs in the much more ferruginous colors, different gill-attachment and narrower spores. Its detailed microscopic characters are not sufficiently known

Inocybe albodisca Pk
Inocybe calamistrata Fr
Inocybe decipientoides Pk
Inocybe fallax Pk
Inocybe fastigiata Fr
Inocybe geophylla Fr
Inocybe lacera Fr
Inocybe lanuginosa Fr -Bres
Inocybe lilacina (Boud ) Kauff
Inocybe pallidipes E & E
Inocybe pretervisa Quél

Inocybe prominens Kauff forma **longistriata**, f nov .— The rimosity is more extensive than in the typical form

Inocybe radiata Pk
Inocybe scabella Fr
Inocybe sororia Kauff
Inocybe virgata Atk.

Inocybe geophylla Fr forma **perplexa**, f nov — This form has the stature and all the other characters of *I geophylla*, except that the pileus, gills, stem and flesh become slowly — finally entirely — diffused with an "apricot buff" or pinkish color after picking, and this color is retained in the dried specimens This form occurs throughout the eastern Rocky Mountain region and thence westward to the Pacific Coast When fresh or in a growing condition it is white like *I geophylla*

Lactarius alpinus Pk
Lactarius aurantiacus Pers. -Ricken
Lactarius lignyotus Fr
Lactarius mucida Burl.
Lactarius parvus Pk
Lactarius subdulcis Fr
Lactarius subpurpureus Pk
Lactarius torminosus Fr
Lactarius turpis Fr.
Lactarius uvidus Fr
Lepiota acutaesquamosa Fr.
Lepiota clypeolaria Fr.
Lepiota cristata Fr.
Lepiota flammeotincta Kauff See Kauffman (15)
Lepiota gloioderma Fr.
Lepiota petasiformis Murrill
Lepiota pulcherrima Graff. See Kauffman (15)
Lepiota rubrotincta Pk.
Leptonia asprella Fr.
Leptonia formosa Fr.
Leptonia occidentalis Murrill
Leptonia serrulata Fr.

**Leptonia subeuchroa**, sp nov —Pileus 1.5–2 cm broad, subpliant, convex, subumbonate, "dark purple-drab" (R ), densely hairy-scaly, even on margin which is at first incurved, flesh thin, concolor towards cap surface, whitish towards gills Gills adnate, subventricose, rather broad, close (or subdistant in age), pure white at first, becoming "seashell pink" (R ), edge concolor, entire Stem 2–3 cm long, 1.5–2.5 mm thick, straight or curved, equal, "dark madder blue" (R ), glabrous and even, naked at apex, stuffed to hollow, whitish within Odor not noted Spores almost even, obscurely angled, ellipsoid-almond-shaped, bright pink under microscope, 8–9(11) × 5.5–7 $\mu$, basidia 4-spored, about 45 × 7 $\mu$; cystidia none, sterile cells on edge of gills indistinct

On mossy log, in forest of cedar, hemlock and maple. Gregarious Mt Hood, Oregon October 16. Collected by C. H. Kauffman

This species stands apart from all its relatives by its obscurely angular spores As to individual species, it differs from *L placida* by the absence of black squammules at apex of stem, from *L. subplacida* and many others, in spore-size and color, from *L euchroa* in the white young gills, from *L chalybea* by its habitat and color, and from *L chloropolia* and *L lazulina* by the non-striate margin of the pileus.

**Leptonia trivalis**, sp nov —Pileus 2–4 cm broad, subpliant, flattened-convex, finally plane and margin elevated, obscurely depressed-papillate, subviscid from a subgelatinous, subseparable pellicle, glabrous, pellucid-striatulate when fresh, "sayal brown" (R ), slowly fading, flesh concolor, fading, subhygrophanous, margin at first incurved. Gills adnate-seceding, rarely with decurrent tooth, close, rather narrow, 2–4(5) mm., white at first, "light pinkish cinnamon" at maturity, edge entire or suberose. Stem 4–8 cm long, 2–4 mm. thick, equal, elastic, cortex cartilaginous, toughish, hollow, flexuous, even, very glabrous, easily splitting lengthwise, hyaline-white. Odor and taste none. Spores globose, obscurely angular, pale under microscope, 7–8 $\mu$ diameter, basidia 4-spored, 25 × 8–9 $\mu$, cystidia none; sterile cells on edge of gills indistinct.

On decayed wood in a cedar swamp. Mt. Hood, Oregon. October 9. Collected by C H. Kauffman.

It seems to be nearest to *L glabra* Murrill, a species from Maine, but differs from it by the gelatinous surface of the pileus, the adnate gills, the much thicker stem and its generally larger size. *L. semiglobata* Murrill also from Maine, a species with a slightly viscid pileus, has squammules on the pileus, a yellowish-gray stem and ellipsoid, angular spores Our species has a general nondescript appearance that allies it to many species of this genus

**Marasmius limonispora**, sp. nov — PILEUS 1–2 cm. broad, submembranous, pliant, "light grayish olive" to "pale smoke gray" (R.) when growing, dingy "pinkish-buff" after reviving in rains, at first even, obscurely radiate-wrinkled in age, the glabrous margin at first incurved, flesh thin, concolor GILLS broadly adnate, relatively rather broad, close, subdistant when pileus expands, whitish, pruinose STEM 7–10 cm long, about 2–2.5 mm. thick, equal, flexuous below but rather strict otherwise, entirely "natal brown" at maturity, or with white apex, pruinose throughout, tubular, concolor within, with a subfibrous cortex, white-myceloid at the base where it is intergrown with moss and humus ODOR and taste none SPORES limoniform in one view, subplano-convex in other view, 9–12 × 6–7 $\mu$, hyaline, smooth, cystidia scattered on sides and edge of gills, lanceolate-subventricose, capitate, hyaline, 65–75 × 12–15 $\mu$, basidia 4-spored, 40 × 6–7 $\mu$

On mosses and humus on the ground in conifer forest, Gregarious. Mt. Hood, Oregon October 16 Collected by C. H. Kauffman.

**Marasmius subnauseosus**, sp. nov — PILEUS 5–15 mm. broad, submembranous, broadly convex to flattened, obtuse, "mars yellow" (R.) on margin, "sudan brown" on disk, glabrous, dry, even, margin at first incurved, flesh concolor, of uniform thickness GILLS broadly adnate, occasionally with a tooth, color "warm buff," crowded, rather broad behind, narrow in front, edge entire. STEM 2–4 cm. long, 1–1 5 mm. thick, tapering down from a somewhat dilated apex, institutious, soon tubular, "raw umber" (R.) except the yellowish apex, covered with a ferruginous pruinosity which is denser at base, even, "mars yellow" within. Odor none; taste tardily nauseous, at length definitely so Spores minute, narrow, subcylindric, 5–6 (7) × 1–1.5 μ, smooth and hyaline, cystidia none, basidia 24 × 5–6 μ; pileus corticate, the surface layer of thick-walled brown cells.

On decayed wood in conifer forest. Gregarious or scattered. Mt Hood, Oregon. September 28. Collected by C. H Kauffman

**Marasmius umbilicatus**, sp nov. — Pileus 2–4 cm broad, slightly fleshy, at very first pale pinkish buff, soon milk-white, *deeply umbilicate*, radiately rugose-wrinkled, glabrous, margin membranous, at first incurved and white pruinose on edge, then repand, flesh concolor. Gills subdecurrent, arcuate, narrow, acuminate at ends, close to subdistant, intervenose, becoming crisped, whitish Stem 3–5 cm. long, 2–3 mm subequal, dilated at apex, tough-cartilaginous, hollow, irregularly compressed and longitudinally furrowed, dark fuscous, darker at base, pallid at apex, glabrous except the scurfy apex, with brownish tomentum at base. Odor and taste none. Spores narrow, elongated-pointed at one end, 9–10 × 3–3 5 μ, cystidia scattered on sides and edge of gills, subfusiform-acicular, about 60 × 7 μ.

Attached to fir needles and debris in fir and hemlock forests. Rather frequent in the mountains of Oregon and Washington. October 5. Collected by C. H. Kauffman

This has the general appearance of *M. delectans* of the Eastern United States, but the pileus is deeply umbilicate, the gills are subdecurrent, the spores of a different shape and it grows in a different habitat.

Mycena acicula Fr.
Mycena amicta Fr –Ricken
Mycena ammoniaca Fr.
Mycena clavicularis Fr.
Mycena epipterygia Fr.
Mycena haematopoda Fr.
Mycena inclinata Fr.–Ricken
Mycena ludea Fr –Ricken
Mycena pelianthina Fr.
Mycena pura Fr.
Mycena rosella Fr.
Mycena rubromarginata Fr.
Mycena vitilis Fr
Mycena vulgaris Fr.

MYCENA STROBILINOIDES Pk — This was a most satisfactory find, and made it possible to record the character of this species in detail Peck described it from the Olympic Mountains, Washington It is a striking little plant, about 3–4 cm tall, with a "flame-scarlet" (R ) pileus, and an "orange" stem, the gills are colored "light salmon-orange" with a flame-scarlet edge. The spores are elliptical, smooth, hyaline, and measure 7 8 × 5-5 5 μ The sterile cells on the edge of the gills are broadly clavate, not very much larger than the basidia, but are colored fiery-orange, and their surface is echinulate-dotted, similarly decorated sterile cells, less highly colored, are scattered through the hymenium elsewhere, and although they have the size of basidia they are clearly differentiated by these markings This is a case, entirely apart from other findings, which supports Buller (7, p 279) in his contention that paraphyses are always paraphyses and here these sterile cells are surely of the nature assumed by him, i e they are "paraphyses" and never become basidia No types of cystidia are present This collection grew on needle beds of the Douglas fir

MYCENA PTERIGENA Fr — This dainty little plant, beautifully illustrated in Fries, *Icones*, Plate 85, Fig 4, occurs in this country in the Eastern mountains as well as in the West I have collected it in the Adirondacks and then again at Mt. Hood It was attached to dead fern fronds lying on the ground The pileus is only 2 5 mm broad, scarcely higher, and at first delicately rose-tinted. At maturity or in age the pileus becomes grayish-brown either entirely or only on the umbo, it is at first subcylindric-subconic, then subhemispherical, and the margin is pellucid-striatulate when fresh The gills are distant, ascending, rather narrow, whitish The stem is 3-4 cm long, half a millimeter or less in thickness, filiform, tough, flaccid, becoming grayish-brown after the rosy tints fade, and is attached by small hairs at the base The spores measure 8–10 × 4–4 5 μ, and are oblong or oblong-subfusiform and hyaline The surface layer of the pileus is composed of large horizontal hyphae.

**Mycena tinctura**, sp. nov (See Plate IX ) — PILEUS 1–2 5 cm. broad, subfleshy, conic-campanulate, obtusely umbonate, "pale pinkish buff" to "drab gray" (R.), umbo "fuscous," at length tinged avellaneous, striate-subplicate, striae subdistant, subhygrophanous, scarcely fading, glabrous, margin at first straight, flesh submembranous, equal, concolor. GILLS ascending, adnate-seceding, rather narrow, without decurrent tooth, *subdistant*, distinct, white, at length gray-tinted, edge entire STEM 4-7 cm long, 1-2 mm thick, equal, even, glabrous, naked at the apex, pale "echru-drab" to "wood brown" (R.), terete or twisted, sometimes compressed-sulcate, cartilaginous, *tough*, strict and elastic, *with a watery juice, becoming dark vinaceous when crushed* ODOR and taste none SPORES 9-11(12) × 5-6(7) μ, ellipsoid, acute at apiculate end, hyaline, smooth, cystidia none, sterile cells on edge of gills saccate but indistinct; surface layer of pileus corticate, composed of 3 to 4 rows of subglobose, vesciculose, rather large cells

On decayed wood and needle beds of hemlock. Cespitose to solitary Mt Hood, Oregon October 7 and 16. Collected by C H Kauffman.

It belongs to the section Lactipedes by virtue of the rather copious watery juice of the stem, which stains the crushed flesh wine color In other respects, it could be referred to the Filopedes. In age the drab and fuscous colors of the cap may fade In addition to the juicy stem it is distinguishable from its relatives by the lack of odor, the narrow, subdistant gills, the spore characters and the absence of cystidia. When growing on wood, the stems may be dwarfed.

NAUCORIA MELINOIDES Fr.-Ricken

NAUCORIA SIDEROIDES Fr.-Ricken

**Naucoria belluloides,** sp. nov — PILEUS 8-20 mm broad, convex, obtuse, dry, glabrous, "chestnut" to "hays russet" (R.), not hygrophanous, margin at first involute, then spreading, even when moist; flesh thin, concolor to ochraceous GILLS *adnexed*, rounded behind, not broad, 3 mm., crowded, "chamois" to "honey-yellow" (R.), edge entire. STEM 2-3 cm. long, 2-3 mm thick, equal or tapering slightly upwards, "cinnamon-rufous" within and without, stuffed axis paler, apex pruinose, glabrous elsewhere, even. ODOR none; taste distinctly bitter. SPORES broadly ellipsoid to oval, rough, dark rusty under the microscope, 7–8 × 5–5.5(6) μ, cystidia none, or few to scattered, short subcylindrical and subcapitate, hyaline, sterile cells on edge of gills nine-pin-shaped, hyaline, obtuse, basidia 32–34 × 6–7 μ, surface of pileus corticate, composed of pyriform, brown cells

On decayed coniferous wood Mt. Hood, Oregon, October 10 Collected by L E Wehmeyer

Very similar in size and coloring to our eastern species, *N bellula* Pk, but differs by its larger spores, adnexed gills, etc

NOLANEA PASCUA Fr.–Ricken — This is a rare species, at once distinguished microscopically by its cruciate-angled spores

**Nolanea latifolia,** sp nov. — PILEUS 2–3 cm broad, companulate-hemispherical, apex truncate-depressed, in age sometimes markedly umbonate but umbo truncate, glabrous, hygrophanous, striatulate to subeven and "hair-brown" when moist, quickly fading to "drab-gray" or ashy on losing moisture, then even, margin at first straight, flesh submembranous, concolor. GILLS broadly adnate-seceding, broad, ventricose, abruptly sinuate near stem, *close*, at first gray-tinted, then "vinaceous-fawn" (R ), somewhat crisp. STEM 5–6 cm long, 2–3 mm thick, strict, equal, elastic, cartilaginous, stuffed to hollow, fragile, persistently grayish-brown to "hair-brown," variegated with silky-white innate fibrils, white-myceloid at the slightly enlarged base. ODOR and taste none or slightly subnauseous SPORES spherical, obtusely angular, tinged flesh-color, 8–9 μ diameter, (10 μ with apiculus), cystidia none; basidia 4-spored, 40–42 × 11–12 μ.

Among moss and debris in forest of fir and hemlock Solitary or subgregarious Mt. Hood, Oregon October 7 and 25 Collected by C H. Kauffman.

I am not at all sure that this may not be *N. occidentalis* Murrill, but if so, that species is very imperfectly described. It differs from Murrill's account by the definitely adnate gills which are closely spaced, not at all distant, and by the fact that they are at first grayish.

OMPHALIA CAMPANELLA Fr.

OMPHALIA DUMOSA Fr.–Ricken

OMPHALIA GRACILLIMA Fr.

OMPHALIA MAURA Fr.–Ricken

OMPHALIA ONISCA Fr.

Omphalia umbellifera Fr. forma **ochraleuca,** f nov. — Plant "cream-color" (R ) in all parts Spores ovoid-elliptical, smooth, hyaline, 6–8 × 4–5 µ, cystidia none Gills distant, broadly decurrent, broadest in middle, few forked Stem sloid, more or less pruinose. Pileus convex-umbilicate to subinfundibuliform, striate-plicate, with a white-appressed pruinosity Collected several times with the characters constant. It differs from the other forms of this variable species mostly in color.

Panus stipticus Fr
Paxillus atrotomentosus Fr.
Pholiota adiposa Fr.
Pholiota erebia Fr
Pholiota discolor Pk.
Pholiota marginata Fr.
Pleurotus albolanatus Fr.
Pleurotus serotinus Fr
Pluteus granulatus Fr
Pluteus cervinus Fr
Pluteus leoninus Fr.
Pluteus nanus Fr.
Pluteus tomentosulus Pk.
Psalliota arvensis Fr

**Psalliota subrutilescens,** sp. nov (See Plate X ) — Pileus 7–12(15) cm broad, oftener 7–9 cm , fleshy, firm, at first hemispheric-oval, at length broadly convex, obtuse or obsoletely subumbonate, at first uniformly covered by a continuous, appressed, fibrillose-hairy cuticle which is "hays brown" to "sorghum brown", during expansion this cuticle is broken up into very numerous, small and appressed, hairy areolae, scarcely in form of scales, and the color changes slowly to shades of vinaceous, e. g. "light russet vinaceous," "brownish-vinaceous," "vinaceous-brown" (R ), etc , remaining darker on disk, the whitish flesh scarcely showing between the areolae, margin even, indistinctly virgate Gills free, at first reaching the stem, becoming subremote, narrow, 4–5 mm , sublinear, crowded, "safrano pink" (R ) when immature, later "vinaceous fawn," finally "sorghum-brown" (R ) or darker, glistening, edge entire Stem 8–12 (15) cm long, oftener 8–10 cm , tapering upwards from a subclavate base, 7–10(12) mm thick at apex, 12–18 mm at base, often subdecurrent at base, at first peronate by a rather thick, densely silky-interwoven, snow-white sheath, which becomes lacerate-torn forming pointed or squarrose scales, and terminating above in the annulus, apex of stem even, silky or minutely sublacerate, stuffed to hollow, tinged vinaceous or subrufescent within, soon soft and putrescent at base ANNULUS at first erect-flaring and white, then deflexed, thick, interwoven-silky, smooth above, densely floccose-scaly and vinescent beneath, with a broad floccose rim when normal, double, persistent, superior ODOR none, taste tardily bitterish-subnauseous SPORES oval-oblong, 5–6(6 5) × 3(3 5) μ, obtuse, smooth, purplish-brown, cystidia none, basidia 4-spored, 30–34 × 5–6 μ

In low moist conifer forests or near alders, usually in humus More frequently solitary or few Not uncommon. Mt Hood, Oregon October 11 Collected by C H Kauffman

This was the only forest Psalliota seen, and although not abundant it occurred singly with some frequency It is superficially similar to *P rutilescens* Pk-Kauff (13), but fundamentally is quite distinct It differs from that species by its double annulus, stuffed to hollow, non-bulbous stem, the narrower spores and the highly developed blematogen. The differentiation of the concrete surface layer of the pileus and of the sheath and annulus take the same course during development as in the case of *P. rodmani* Pk studied by Atkinson (1) The sheath on the young stem, along with the portion up to the margin of the pileus, includes the partial veil as an interior layer — thin along the stem — and this composite sheath can be easily peeled off from the stem at this stage.

PSATHYRA PENNATA Fr-Ricken

PSATHYRA PERSIMPLEX Britz-Kauff (12, p 270)

**Psathyra fragilissima**, sp nov (See Plate XI) — PILEUS 2–5 cm broad, 1 5–3 cm. high, very fragile, at first broadly conic and obtuse, conic-campanulate at maturity, hygrophanous, "light cinnamon drab" (R) and even when young and moist, later "benzo brown," at first covered by snow-white evanescent floccose-fibrillose, small and superficial scales, "pale pinkish buff" and even when dry, soon glabrous, margin at times evanescently appendiculate, flesh thin, equal, fragile, concolor GILLS ascending, adnate-seceding, relatively narrow, 3–5 mm., crowded, soon "hair-brown" then "fuscous" (R), edge at first minutely white-flocculose. STEM long and slender, extremely fragile, 10–15(18) cm by 3-5(6) mm , equal or tapering slightly upwards, pure white, glabrous, scurfy and substriate at apex, hollow, even, strict but becoming flexuous, cartilaginous, easily splitting ODOR and taste mild or slightly nutty SPORES elliptical, regular; obtuse, smooth, 13 15 × 6 7 μ, purple brown, *cystidia none*, sterile cells on edge of gills short and broadly nine-pin-shaped, i e capitate, 45 × 12-15 μ, basidia 4-spored, 30-32 × 12 μ, upper layer of pileus slightly differentiated, composed of 3-4 rows of vesiculose, hyaline cells, forming a subseparable pellicle, interior trama slightly tinged with drab

On decayed leaves, needles and humus in mixed forest Gregarious Mt Hood, Oregon, October 12 Collected by C H Kauffman

This differs from both of the preceding by lacking cystidia on the sides of the gills It is distinguished in general, by the pure white universal veil, long white stems, non-striate pileus, large spores and by the shape of the sterile cells on the edge of the gills. It belongs to the section Fibrillosae

**Psilocybe ochraeceps,** sp nov — PILEUS 1-3 cm broad, at first broadly oval, at length subhemispherical, obtuse or obscurely short-pointed on centre, unexpanded, about 1 cm high at maturity, pelliculose, lubricous, subhygrophanous, at first "yellow-ochre" (R ) to "antimony-yellow," glabrous and even, margin at first incurved and white-cortinate, flesh concolor (moist), whitish (dry), easily split radially, toughish across radial section GILLS adnate-seceding, ascending, ventricose, rather broad, 3 5 mm , closely spaced at margin of pileus, subdistant near stem, white at first, then "hair-brown," sprinkled by the spores, edge entire STEM 4-9 cm long, 1-2 5 mm thick, equal above the tomentose-enlarged base, reddish-fuscous within, pale-fuscous beneath a distinct cortinate white coating of fibrils, narrowly white-stuffed in the axis, very slightly viscid ODOR and taste slight, subnauseous SPORES 8-9 × 4-5 μ, elliptic-oblong, smooth, obtuse, purple-brown, cystidia none, sterile cells inconspicuous

Base of stems imbedded in humus or rotten wood Gregarious Mt. Hood, Oregon, September 28 and October 7. Collected by C. H. Kauffman.

It belongs to the section Tenaces. A very distinct plant, whose pileus remains unexpanded and on drying *in situ* becomes radially undulate-plicate, its margin closing in on the stem. The stem is distinctly sticky to the tongue, indicating an outer veil continuous with the pellicle of the pileus. At first and for a time, the cortinate covering gives the stem the appearance of being white.

**Psilocybe olivaceotincta**, sp. nov.—Pileus 1.5–3 cm. broad, fragile, at first obtusely campanulate, then expanded to plane, hygrophanous, "citrine-drab" (R.) and faintly striatulate when moist, "olive-buff" or "pinkish-buff" and atomate when dry, glabrous, margin at first incurved, flesh thin, .5–1 mm., concolor. Gills broadly adnate, close to subdistant, thin, rather broad, at first "pale olive buff," then "citrine drab" (R.), edge very entire. Stem 3–5 cm. long, 1.5–2.5 mm. thick, equal or tapering downwards, toughish, becoming rigid-brittle, "cinnamon-rufous" upwards, "chestnut brown" downwards, glabrous except the minutely scurfy apex, concolor and minutely tubular within. Odor and taste none. Spores elliptical, smooth, 10–12 × 5–6 μ, distinctly purple-brown under the microscope, cystidia none, sterile cells on edge of gills, filiform, cylindrical, hyaline, 3–4 μ diameter, trama of pileus homogeneous.

On moist thick humus and rotten debris in conifer forest. Mt. Hood, Oregon, October 6. Collected by C. H. Kauffman.

Sharply distinct by the contrasting colors of pileus and stem.

Russula borealis Kauff.
Russula delica Fr.
Russula emetica Fr.
Russula expallens Gill.
Russula fallax Cke.
Russula flava Romell
Russula Murrillii Burl.
Russula pectinatoides Pk.
Russula Raoultii Burl.
Russula subolivascens Burl.
Russula xerampelina Fr.
Stropharia ambigua (Pk.) Zeller
Stropharia stercoraria Fr.

**Stropharia fragilis**, sp. nov. (See Plate XII.)—Pileus very fragile, 3–7 cm. broad, at first subhemispherical then campanulate-expanded, obtuse, at length plane-subrepand, very hygrophanous, "army-brown" to "wood brown" (R.) and striatulate on margin when moist, fading to "pinkish buff" and even when dry, finally becoming finely radiately wrinkled, at very first with concentrically disposed, superficial, hairy-silky to subfloccose, white, evanescent scales, soon denuded, disk brownish in age, margin at first incurved, flesh thin, 1–1 5 mm thick, concolor. GILLS adnate-seceding, medium broad, 4–6 mm., nearly plane, close, soon "drab"-colored, then "hair-brown" or darker, edge white-flocculose STEM very fragile, 7–10 cm long, 4-5 mm. thick, thicker at base, tapering slightly upwards, from the subclavate base, *white*, lacerate floccose-silky up to the annulus, apex pruinose, silky above ring, stuffed to hollow, with cartilaginous cortex, white within ANNULUS membranous, soon deflexed, white, coronillate on upper surface, densely silky or floccose below, distant about one third from apex of stem, derived from the universal veil, partial veil very scanty SPORES elliptic-oblong, 6 5–8 × 3 5–4(4 5), smooth, dark purplish-brown under the microscope, cystidia on sides and edge of gills, ventricose-sublanceolate, obtuse, hyaline, thin-walled, pedicel rather stout ODOR and taste mild or slight.

On the ground in a swampy cedar and hemlock forest Cespitose or subcespitose. Mt. Hood, Oregon, Ocbober 16 Collected by C. H Kauffman

It belongs to the group Spintrigeri. Without a knowledge of the detailed characters, it could easily be identified with *S. spintrigera* Fr. It has not at all the habit of *Hypholoma appendiculatum* with which Fries (10) compares his species. Our species differs from *S. spintrigera* in its striatulate, scaly pileus, the longer stems, broader gills, and, as far as is known, by the presence of cystidia on the sides of the gills The spores are of the same size as given by Rea (19) for *S spintrigera*, but Rea departs from the sizes of the plant given by Fries and others by including here a long-stemmed plant. According to Fries (*l c*) the gills are very narrow, 2–4 mm. wide, although this conception has also been varied by later authors. Lange (16) describes a variety of *S. spintrigera* and has kept close to the Friesian conception with respect to the habit assigned to it by Fries.

**Stropharia squamosa** Fr (See Plate XIII ) -- Reading between the lines one soon realizes that mycologists are continually beset with the query What is the typical *S squamosa?* The method pursued in the past, of attaching several varieties under this name, has but complicated the situation, for it seems easier to collect the varieties than to get clear the correct idea of the Friesian species, at least in this country In support of these statements is the uncertainty shown in the works of various authors concerning the microscopic characters of this plant and its varieties Persoon is still given credit for naming it — in fact he named it twice — but no descriptions can be found which are at all complete, which do not practically copy that of Fries from *Monographia* Ricken (20) publishes a figure that gives the general appearance of the plant, but since it is difficult to reproduce the changing colors during the development or under different weather conditions, one does not get a very clear idea from such a figure

The plants shown in our photograph agree well with the Friesian description and that of Ricken The stems are slender, 10–15 cm long and 3–6 mm thick, at first strict, tough, and lacerate floccose-scaly up to the annulus The pileus is at first hemispherical with a subconic umbo, viscid when wet, and covered by scattered, superficial, evanescent, silky-white scales, beneath which it is colored "ochru-olive" (R ), darker towards the "chestnut"-colored umbo, the umbo later becomes much less prominent, or the pileus may be merely obtuse It is 3–5 (6) cm. broad, and when it loses moisture, by drying *in situ*, it becomes "ochraceous-buff" and finally, "yellow-ochre" The gills are broadly adnate, 6–10 mm broad, at first "pale mouse-gray" (R ), then finally "fuscous"-colored The odor is slight, but occasional penetrating whiffs of it can be easily noticed The taste is mild These plants have spores measuring 12–14 × 6–7.5 $\mu$, elliptical, smooth and purple-umber under the microscope Cystidia are lacking on the sides of the gills, while the edge is provided with filiform obtuse sterile cells, 50–60 $\mu$ long, and 3–4(5) $\mu$ thick The annulus is somewhat distant from the pileus, at first erect-flaring, then deflexed, rather narrow, and strongly coronillate on its upper surface, at first it is white-lutescent, then stained above by the spores, and floccose-silky on the under side The plants grow loosely gregarious on humus or very rotten wood in open coniferous forests They were my first collection of the species which seemed to me to be typical, rather than varieties

TRICHOLOMA EQUESTRE Fr
TRICHOLOMA FARINACEA Murrill
TRICHOLOMA PANOEOLUM Fr
  var CESPITOSUM Bres
TRICHOLOMA PERSONATUM Fr
TRICHOLOMA PESSUNDATUM Fr
TRICHOLOMA ROSEIBRUNNEA
  Murrill
TRICHOLOMA RUTILANS Fr
TRICHOLOMA SUBPESSUNDATUM
  Murrill
TRICHOLOMA SYLVATICA Pk

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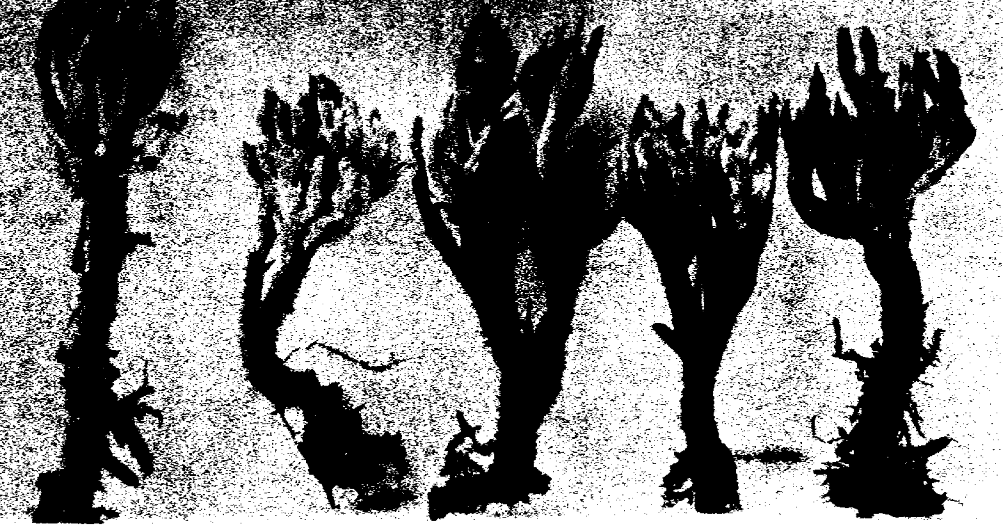
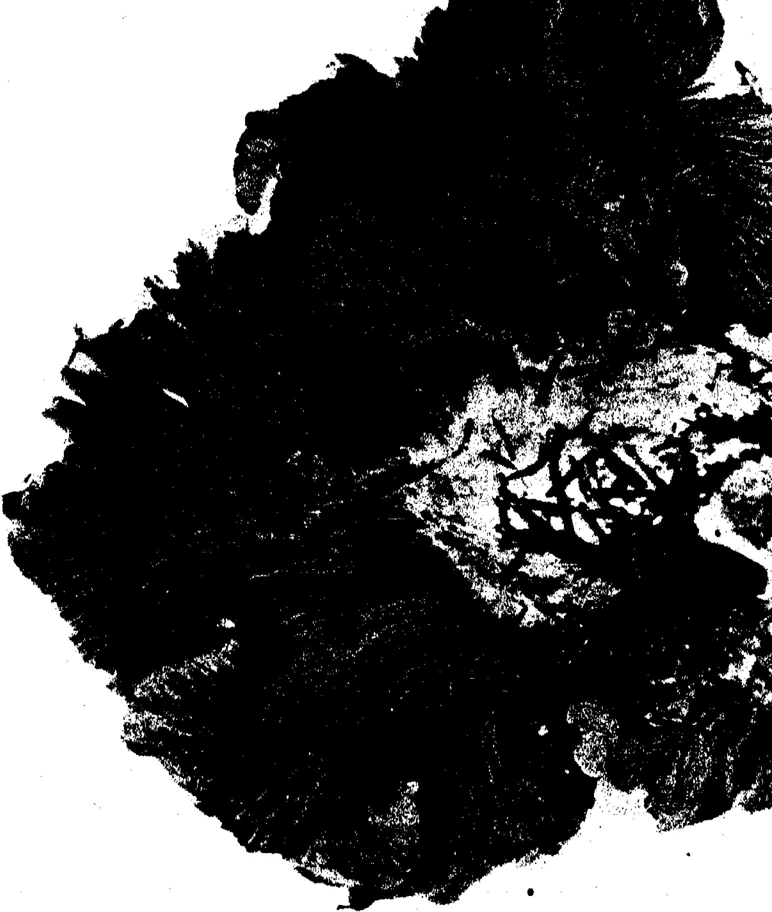


FIG. 1. LACHNOCLADIUM ORNATIPES



# THE DEVELOPMENT AND TAXONOMIC POSITION OF *APIOSPORINA COLLINSII* *

G. B. SARTORIS AND C. H. KAUFFMAN

### HOST RELATIONS

THE fungus discussed in this paper is well known to American mycologists as "*Dimerosporium Collinsii*" (Schw.) Thüm. It is a parasitic fungus which grows on the under surface of the leaves of *Amelanchier canadensis*, causing a decidedly characteristic witches'-broom (Fig. 12). During the latter part of March or early April the mycelium appears on the under surface of the leaves which have just emerged from the bud. Perhaps it arises from the ascospores, which are found on the old leaves still attached to the twigs of the witches'-broom, to which region the infection of new leaves is usually confined. However, some new infections do occur, from time to time, in adjacent spots. In the case of most of the trees that were observed for three years, this was generally true.

The branching mycelium soon covers the entire dorsal surface of the leaf with a brownish mat (Fig. 1). Conidia (Fig. 2) are borne profusely and give the mycelium a slightly greenish tinge. These are produced until the middle of June or the first of July, when the perithecia begin to form. By the fifteenth of July the latter are visible to the naked eye. They first appear as scattered black dots near the mid-rib, and later progress towards the margin of the leaf. By the middle of August they are so numerous that most of the under surface of the leaf is covered by a black stroma-like layer mixed with perithecia (Fig 14) The leaves turn brown, and curl up, the dorsal side outward, and remain on the witches'-broom until the following spring and often even longer By September the asci are formed in the perithecia, but the spores do not assume their characteristic shape until January, maturing by the end of February The ascospores are hyaline, smooth and one-septate, the upper cell being much larger than the lower one, they measure 11–15 × 3–5 $\mu$

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The junior author made all the studies herein recorded that deal with the life-history and host relations. The taxonomic account and the discussion have been added by the senior author.

The characteristic of the disease, i e the production of witches'-brooms, leads one to believe that the mycelium is perennial, and lives over winter in the wood, or on the old leaves of the abnormal growth. But this could not be confirmed by examination, nor did the witches'-brooms, when placed in healthy trees, spread the disease The ascospores seem to be the only active agent in disseminating the fungus

Although the conidia are borne in large numbers in the spring, they are a negligible source of infection, as has been noted above. All experiments with them failed to produce the disease It may be that the leaves on the witches'-broom are somewhat less vigorous, and therefore more susceptible to infection

## THE LIFE-HISTORY OF THE FUNGUS

### *Material and Method*

Collections of material were made from October through December, 1922, and throughout the year 1923, at Whitmore Lake, Michigan The material was fixed in several killing fluids, the most satisfactory of which were medium Flemming's and Bouin's, the latter being especially good for mature perithecia, as it softened the walls. Embedding in paraffin was done in the usual manner Sections were cut 5 to 7 $\mu$ in thickness The stains used were Haidenhain's haematoxylin, Flemming's triple stain, and safranin-anilin blue. The first one gave the best results.

### *The Vegetative Plant*

The mycelium is dark brown, appearing black in mass It consists of uninucleate cells with thick walls, and a thin layer of cytoplasm lining them. This mycelium is superficial until mid-summer, or until the perithecia begin to form At that time the hyphae become intercellular There are no haustoria formed, and the mycelium very rarely enters the cells The intercellular hyphae and those next to the epidermis have thin, hyaline walls, and are full of a fine granular material They finally invade the interior of the leaf as far as the upper epidermis From the mycelium on the surface of the leaf the conidiophores arise. They are erect, and two to three cells long (Fig. 2) At the tip of each is formed a unicellular conidium, which is uninucleate and lemon-shaped.

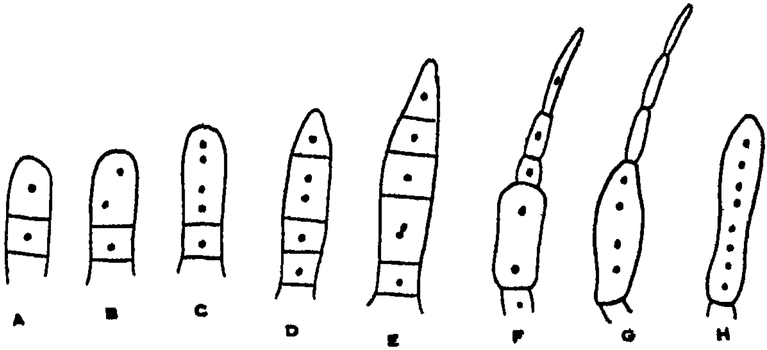

FIG 5 Diagrams illustrating the Behavior of the Nuclei preceding and during the Development of an Ascus

### *The Perithecium*

The coils of mycelium which are formed during the first part of July are the beginnings of the perithecia (Figs 3 and 13) In the center of each coil are one or two slightly differentiated hyphae which contain fine, granular protoplasts. These stain a deep blue with Haidenhain's haematoxylin. They are enveloped by a number of vegetative hyphae which become closely packed to form the perithecial wall (Figs 5, 6 and 7) The central cells continue to divide until many cells are formed, always in a uninucleate condition (Fig 4). When the wall of the perithecium is completely formed, the central coil sends out a fan-shaped group of hyphae, which grow until they reach the top of the perithecium (Figs 8 and 9).

Prior to the formation of the fan-shaped group of hyphae, conditions arise in certain cells which are suggestive of the manner in which a binucleate cell is formed in a young ascus Some terminal cells (Text Fig. 5 A) become binucleate by a nuclear division which is not followed by wall formation between the daughter nuclei (Text Fig 5 B) These in turn divide forming four nuclei (Text Fig 5 C) Then cell walls are laid down between the homologous members of each pair of granddaughter nuclei, thus forming three cells, the central one of which is binucleate (Text Fig 5 D) Then the two elements of the binucleate cell fuse (Text Fig 5 E) This, then, is the fusion which initiates the growth of the ascus Probably before this fusion takes place, the terminal, uninucleate cell will have grown into a slender hypha (Text Fig 5 F and Fig. 15), which is one of the fan-shaped group of hyphae The ascus now increases in length and breadth, while the slender hypha terminating it gradually degenerates, and is finally cut off at the cross-wall (Text Fig 5 E, F and G, and Fig 9) Meanwhile the three nuclear divisions which occur in the ascus after fusion has taken place result in the eight-nucleated ascus (Text Fig. 5 H, and Figs. 10, 16 and 17)

### *Formation of the Ascospores*

The eight nuclei formed arrange themselves into a single row which extends the full length of the young ascus In that position another division occurs preparatory to the formation of the two-celled ascospore. Prior to this division, there is a condensation of the cytoplasm around the dividing nuclei At this stage there are eight dark staining masses in the young ascus. The nuclei then divide, one daughter nucleus remaining in the center of the mass, while the other moves to the lower end Now there are cleavages in the cytoplasm surrounding each pair of nuclei, and in these cleavages the spore walls are laid down Walls also form between the members of each pair of nuclei, resulting in a two-celled spore, the upper cell of which is much larger than the lower (Fig 18). The endosporium is formed first, then as the remainder of the cytoplasm in the ascus draws away from the spores, the exospore is laid down. As the spore matures the exospore becomes thicker, and the cytoplasm denser. The mature ascus then contains eight, two-celled spores (Figs 11 and 19) A nucleus can readily be seen in each of the cells of the ascospore

### *The Pycnidium*

In the fall the pycnidia (Figs 20 and 21) appear on the upper surface of the infected leaves Their development begins when the intercellular mycelium has spread throughout the tissue of the leaf They are flask-shaped bodies, almost entirely embedded in the leaf, with short, thick necks protruding The walls are made up of somewhat loosely interwoven hyphae From the inner side of these, long slender hyphae arise, which form the pycnidiospores These are spindle-shaped cells In the center of each one there is a large nucleus, which really forms the greater part of the cell and which is said to be a characteristic of spermatia However, there is no evidence that fertilization is effected by their agency In addition to the small hyphae which form the pycnidiospores, there are present larger hyphae which are composed of short chains of angular cells. These are somewhat deeper staining than the pycnidiospores. Their function is not known

### *The Fungus in Culture*

Cultures were obtained from conidia collected in May Single spores were isolated and transferred to artificial media The mycelium which develops on media is similar in every respect to that on the host. On solutions of sugars of various concentration, and of peptone with sugar, when the filter-paper pads of Leonian (7) were used, the fungus was grown with ease On malt-extract, in solutions containing various concentrations of from 0 5 to 20 per cent, it produced especially large amounts of mycelium in the higher percentages

On Leonian's agar and on heavy oatmeal agar, mycelium was very luxuriant On adding 1 per cent levulose and 0 6 per cent potassium nitrate to the oatmeal agar, the fungus proceeded to develop dark brown bodies The work had to be discontinued at this point, so that no final report can be made

The fungus grows best, in the media mentioned above, at a temperature of about 25° C It grows fairly well at 8° C, and it will even show slight growth at a temperature near the freezing point

## TAXONOMIC RELATIONS AND DISCUSSION

"*Dimerosporium Collinsii*," the fungus discussed in the preceding pages, has been known in this country for a long time, it was first described by Schweinitz (10) in 1832 as *Sphaeria Collinsii*. The specimens so named were sent to him by Dr. Zacchaeus Collins The host is not mentioned, Schweinitz (*l c*) says the fungus occurs on the under side of an unidentified leaf ("in aversa pagina folii ignoti").

Later Berkeley (*Grevillea*, IV 106) described a fungus under the name of *Sphaeria papilionaceae* B. & C from material collected in South Carolina by Ravanel, on what was "apparently some rosaceous plant" At the same time he named a fungus on "Mespilus" (=Crataegus?) from Massachusetts, *Sphaeria Russellii* B & C. Later (*Grevillea*, XV 82, 1887) he refers both of these to the genus Lasiosphaeria and remarks that they are synonymous with *Dimerosporium Collinsii* Thüm Ellis (3), perhaps on the strength of Berkeley's opinion, does the same. We have not seen these specimens, if they exist, but are inclined to doubt the synonymy, on the ground that the hosts are unusual.

Meanwhile Peck (8) found it on *Amelanchier canadensis* in

New York State, and, under its original name of *Sphaeria Collinsii* Schw., gives for the first time an account of its effect on the host and of the microscopic characters of the fruiting stage. His account of the relations between the fungus and host follows:

> This remarkable Sphaeria was found in considerable quantity in the locality mentioned. It attacks all the leaves on an affected branch, and even the branch itself gives indications of the presence and influence of the fungus. It is more or less contorted, swollen and deflected towards the ground. The upper surface of the leaves assumes a dark-green or lurid hue, the lower surface being wholly occupied by matted filaments, the subiculum of the Sphaeria. This is at first olive-brown in color, but at length black spots appear upon it. These gradually enlarge until the whole surface becomes black. With this change in the color of the subiculum, the perithecia appear, but they do not, apparently, perfect their spores until the following spring, spore-bearing specimens having been found in May. The affected leaves adhere to the branch during the winter and the early part of the following summer. These dry leaves, when seen among the surrounding green leaves that put forth before these have fallen, together with the drooping branch that bears them, are deceptively imitative of dead leaves on a branch that has been broken down but still adheres by a shred to the parent trunk. The young fungus commences its growth before the old one of the previous year has disappeared. I have taken from the same tree, at the same time, old leaves bearing the mature Sphaeria, and young leaves bearing the subiculum and young perithecia of the succeeding crop. The fungus does not appear to kill the branch it attacks.

Thümen (12) transferred it to the genus Dimerosporium, and Saccardo in the *Sylloge* (9) compiled the accounts of Schweinitz and Peck under the name *Dimerosporium Collinsii* (Schw.) Thüm.

Finally, Von Hohnel (6), after an examination of such exsiccati as were accessible to him, decided that an ostiole was formed by the perithecium, placed it in the Sphaeriaceae, and erected a new genus for it. It thus became *Apiosporina Collinsii* (Schw.) v. H. He also considers *Plowrightia phyllogena*, a California fungus described by Harkness, identical with it; in this disposition of *P. phyllogena*, Theissen and Sydow (11) concur.

Schweinitz (10) had placed his fungus in the tribe Byssisedae in the old, comprehensive genus Sphaeria Fr. Here one finds it located near species which would today be placed in such widely separated genera as Rosellinia, Herpotrichia and Hypomyces.

Peck (8) remarks that it shows similarity to "*Sphaeria morbosa*" (=*Plowrightia morbosa* and also *Dibotryon morbosa* Schw ) Theiss & Syw. (11)

As to its hosts, *Amelanchier canadensis* (L ) Medic seems to be the only Eastern host known on which the fungus occurs Ellis (3) reported it also on *A alnifolia* Nutt , from the Sierra Nevada Mountains of California This was the host given for "*Plowrightia phyllogena,*" by Harkness

As Von Hohnel (6) has already pointed out, even a superficial study of the perithecia shows at once that the fungus is not a Dimerosporium, and the additional fact brought out in this paper that its mycelium invades the host leaf and is in no sense superficial, removes it clearly from the order Poriosporiales. But Von Höhnel came to the conclusion that the perithecia are ostiolate, this is not surprising, considering that he worked with old collapsed herbarium specimens He notes, however, that the ostioles are not typical ostioles. In studying this point, we found that there was no basis for the notion that an ostiole of the sphaeriaceous type is here differentiated To be sure, weaker or thinner areas may arise in the walls of exceptional perithecia, but there is no constancy of position of such areas In such cases the mature perithecia probably break first at these points, but for the most part they break open irregularly in the manner of similar non-ostiolate perithecia. Except for this lack of a differentiated ostiole, it would be difficult to find objections against placing the fungus in the Sphaeriaceae It would appear that by its habit and development it approaches such ascomycetes as *Neopeckia Coulteri* (Pk ) Sacc and *Herpotrichia nigra* Hartig, from which it differs mainly in the character of the ascospores These species also are foliicolous and produce a highly developed superficial mycelium in which the perithecia are imbedded

Two other groups of ascomycetes can be considered as possible receptacles for this species, the Dothidiales (sense of Theissen & Sydow) and the Aspergillaceae (sense of Fisher in Engler and Prantl's *Pflanzenfamilien*) In both true ostioles are lacking The extension of the definition of stroma, so as to include what we here consider the perithecial wall, might permit the inclusion of this species in the genus Armatella Theiss and Syd, a monotypic genus in the Dothidiales whose one species has already been taken out of the Dothidiales by Von Hohnel (5) The difficulties arising from assigning to structures, whose origin is unknown or very doubtful, the term 'stromatic,' is only too well known to careful workers in the ascomycetes to need discussion here. In the Aspergillaceae the asci are irregularly disposed within the ascocarp and in general have different habits.

*Apiosporina Collinsii* is, therefore, when considered from a purely taxomic standpoint, an anomaly In another sense, however, it is to be considered as belonging to the type of organisms which, by virtue of certain characters, are intermediate in a phylogenetic arrangement That its connection with the Sphaeriaceae is far closer than with any other group is shown by its characters other than the lack of an ostiolate perithecium In addition, the developmental history of the structures that make up the perithecium points to the same conclusion

The manner of approaching the problem of phylogeny within the ascomycetes, as presented by Dame Gwynne-Vaughan (4), is well adapted for inquiry into the question of relationships of the species before us In her introduction to the division of "Plectomycetes," in which the Perisporiales are placed by this author, one finds the statement "In none of the Plectomycetes are the more complicated forms of sexual apparatus reached, the tricogyne and oögonial region are never multicellular and the antheridium never becomes a spermatium" In the Pyrenomycetes, on the other hand, there is generally a structure composed of differentiated hyphae, which are more or less coiled or intricate among themselves, certain cells of interior hyphae as shown by their staining properties are considered as the archecarps. The few facts so far noted for *Apiosporina Collinsii* seem to indicate that this fungus belongs to the pyrenomycete division as limited by Gwynne-Vaughan In the time available for the study of developmental stages only the bare outlines of the process could be established However, it seems clear, from the figures herewith presented, that a coiled archecarp is present, and that the further development is of the type which has been worked out for *Polystigma rubrum* (1) or *Gnomonia erythrostroma* (2) In these, as in *Apiosporina Collinsii*, so-called "spermagonia" are a part of the life-history

Taking all these facts into consideration, we consider the name given to this ascomycete by Von Hohnel valid, and its position in the Sphaeriaceae fairly assured With regard to the characterization which Von Hohnel gives to his genus, Apiosporina, it is evident that it needs emending The fungus is intramatricular (not superficial) and the perithecia are *not* "with ostioles "

A word may be said concerning the use of the term 'spermagonium,' as applied to certain pycnidial structures in the ascomycetes. The term has been most tenaciously retained by the cytological workers, because to morphologists it is the backbone of a theory — the theory of a once functional sex-organ that has become functionless Whenever such pycnidia bear a certain type of minute pycnidiospore, they are called 'spermatia,' in spite of the fact that this word has excellent meaning in certain plants where spermatia are functioning male cells. When pycnidia of very similar structure and position bear conidia, small as they may be, provided they germinate and the germtubes are known to infect the host, then they are no longer 'spermatia,' if we understand the idea of these students of morphology. But to be logical, one can just as easily assume that pycnidia, which produce, say, several-celled, brown spores, have descended from ancestral antheridia by changes no more disturbing than that of these 'spermatia' which have lost not only their sex-functioning ability, but also their normal position near the female organs. If the term 'spermagonium' is to be retained, then it should include all pycnidia formed by species of ascomycetes, for the germinating or non-germinating ability and perhaps even the infecting ability is not necessarily absent because it has not been brought about. Nor are these types of pycnidiospores the only ones which defy germination rules, for species of the genus Libertella, of Phomopsis and of other genera, have been studied, whose conidia resisted all the *usual* means applied to cause germination.

The authors are under great obligation to Maria K Sartoris for making the drawings of Figures 1, 2, 3, 4, 5, 6, 15, 16, 17, 18, 19 and 20, and to Dr Ernst Artschwager for aid in taking the photomicrographs.

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## DESCRIPTION OF PLATES

The line drawings were made with the aid of a Spencer microscope equipped with a 10 X ocular and 2 mm, 1 40 N A oil immersion objective and 1 40 N A condenser The photomicrographs were taken with a Bausch & Lomb microscope stand equipped with a Leitz 6 X periplan ocular and 2 mm 1 40 N A oil immersion objective and 1 40 N A condenser

### PLATE XIV

FIG 1 Cross-section of a leaf of *Amelanchier canadensis*, showing the vegetative uninucleate mycelium of *Apiosporina Collinsii* The aërial mycelium consists of branching hyphae, the basal cells of which are large and irregular, and have thick brown walls and a thin layer of cytoplasm The intercellular mycelium is more regular, the walls are thin, hyaline, and the cells are filled with a fine granular cytoplasm Haustoria are not formed, and the mycelium rarely enters a cell

FIG 2. The conidiophores and the uninucleate conidia

### PLATE XV

FIG 3 A perithecium, initial in cross-section consisting of a coil of a few differentiated hyphae, surrounded by vegetative hyphae

FIG 4 The origin of a coil from three hyphae in vertical view The vegetative hyphae beginning to envelop it, all cells are uninucleate

FIG 5 The cells of the coil have divided to form many cells, and the vegetative hyphae are forming the beginnings of the perithecial wall

FIG 6 The coil has become greatly enlarged, and the perithecial wall is thicker and more compact, all cells are uninucleate

### PLATE XVI

FIG 7. The perithecial wall is completely formed, and the coil now consists of many cells, and is about to give rise to the ascogenous hyphae Magnified 940 times

FIG 8 A fan-shaped group of slender hyphae arising from the coil (Ascogenous hyphae!) Magnified about 940 times

FIG. 9 A more advanced stage of the fan-shaped group of hyphae showing the long, slender hyphae, which will degenerate, and enlarged, dark staining, basal cells which will give rise to the asci Magnified 700 times.

FIG 10. Young asci formed from the basal cells of the fan-shaped group of hyphae Magnified 530 times.

Fig. 11. The perithecium is almost mature. Each ascus contains eight two-celled ascospores.

Fig. 12. The witches'-brooms, caused by *Apiosporina Collinsii* on *Amelanchier canadensis.*

Fig. 13. The intricate coil by which the perithecium is initiated. Magnified 1060 times.

Fig. 14. Cross-section of a leaf of *Amelanchier canadensis*, showing typical arrangement of perithecia. Magnified 56 times.

Fig. 21. A photograph of a pycnidium. Magnified 940 times.

## PLATE XVII

Fig. 15. One of the slender hyphae in the fan-shaped group, the basal cell of which is binucleate. The two nuclei are approaching each other just prior to fusion. The cell in which the fusion takes place will enlarge to form the ascus; the fusion nucleus, by successive divisions, will give rise to the ascospore nuclei.

Fig. 16. The young ascus has started to enlarge and the second nuclear division has just been completed, giving rise to four nuclei.

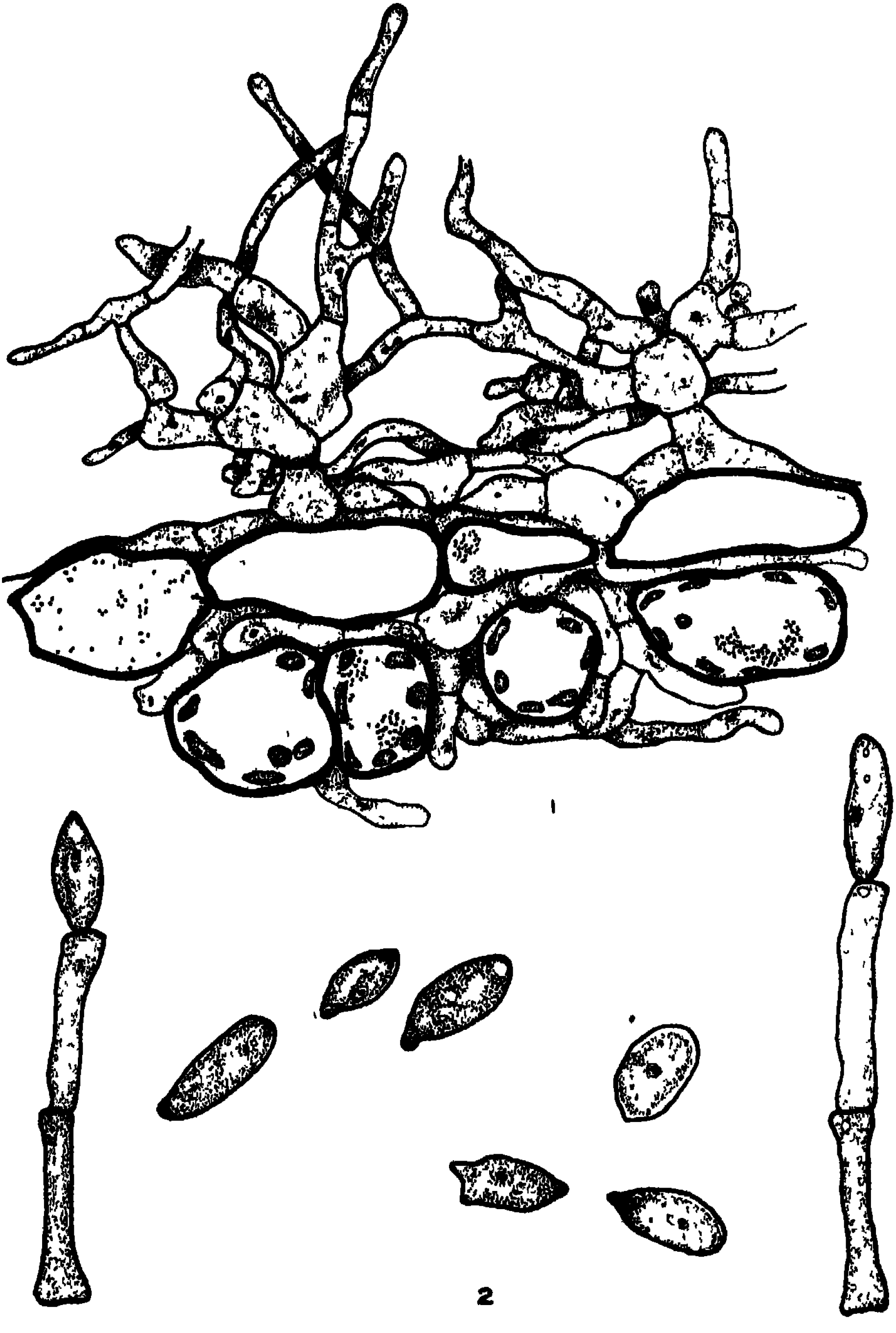
Fig. 17. The young ascus containing eight nuclei. The cytoplasm is beginning to condense around the nuclei, and the final division of the nuclei is about to take place.

Fig. 18. The final nuclear division has taken place. The ascus now contains sixteen nuclei from which eight two-celled spores are forming. The cytoplasm not used in the formation of the ascospores shrinks to the wall of the ascus and disintegrates. The connecting substance between the two cells of the young spore does not stain.

Fig. 19. Mature ascus containing eight one-septate spores, the upper cell of which is much larger than the lower.

Fig. 20. The pycnidium embedded in the tissue of the leaf except for the short, thick neck, which breaks through the epidermis and protrudes slightly. The wall of the pycnidium is formed of loosely interwoven hyphae. Slender hyphae consisting of small cells with comparatively very large nuclei arise from the wall, and usually degenerate before giving rise to mature conidia. Besides these, there are short chains of larger, irregular, dark staining cells of unknown function.

# PLATE XIV



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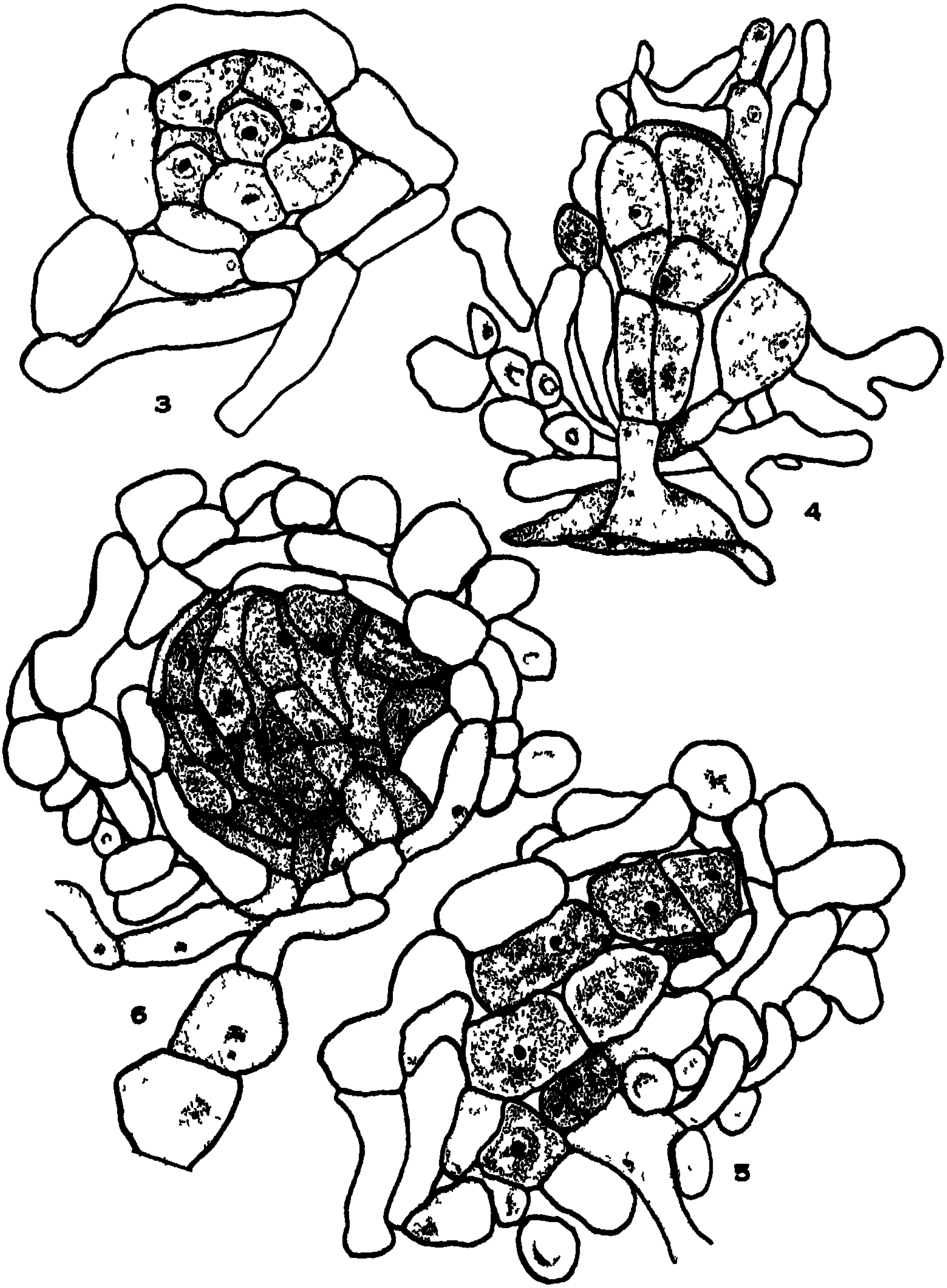

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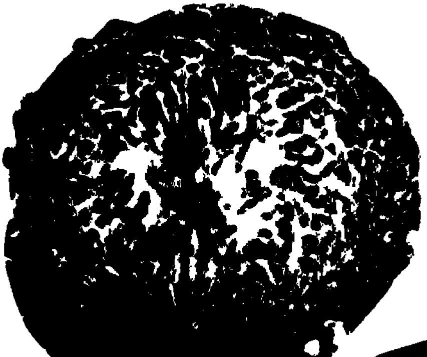
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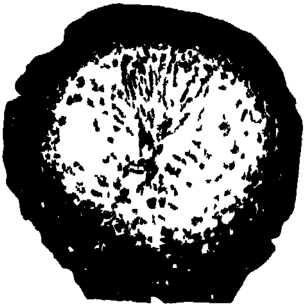
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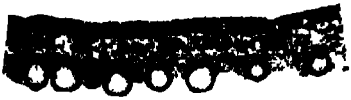
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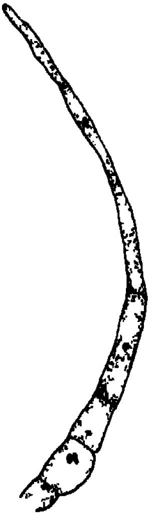
# PLATE XVII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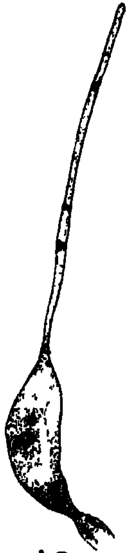
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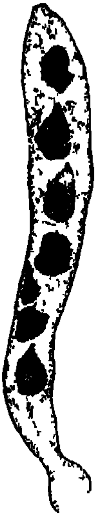
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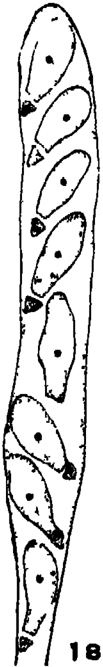
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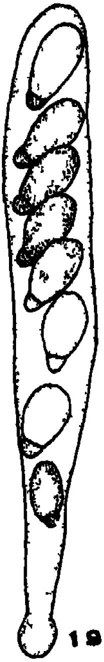
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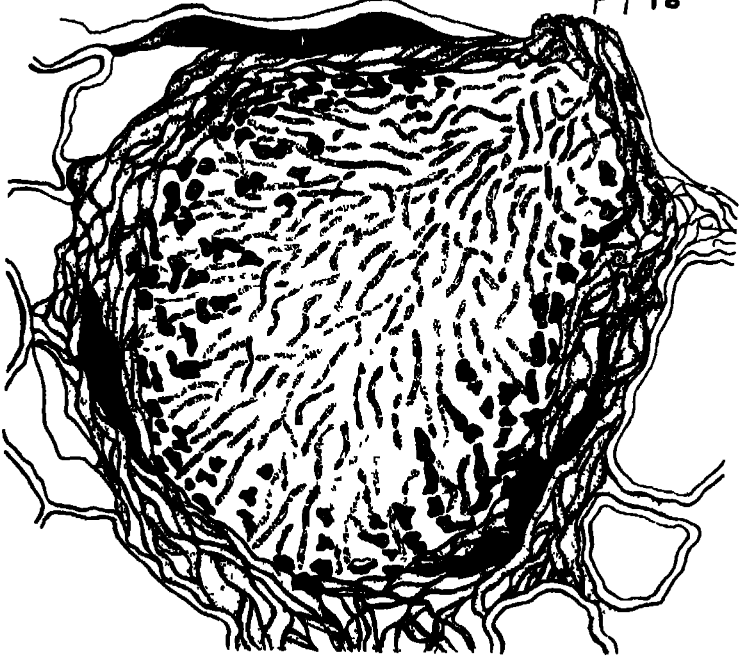
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# THE REACTIONS OF BEAN RUST GROWN ON LEAVES IN SOLUTIONS*

CHARLES W. WATERS

## INTRODUCTION

IN all of the studies and investigations that have been made on the rusts, investigators have been greatly handicapped by the fact that the parasite is so highly specialized and such a persistent obligate. Up to the present time no one has ever succeeded in cultivating them upon any medium other than their natural host Undoubtedly, numerous attempts have been made, but with the exceptions of the recorded attempts of Brefeld (2), Ray (9) and Carleton (3), little or no mention is made of them in the literature.

De Bary (1), as early as 1863, settled the question that the rust organism was the cause of the disease and not the result, and stated that the parasite was unable to exist outside of the living host.

Marshall Ward (11) grew sterilized host plants in nutrient solutions and succeeded in keeping a pure culture of the rust organism, *Puccinia dispersa*, growing on the plants while under these conditions He also detached portions of the host after inoculation and endeavored to secure infection in these parts, but his results were negative.

Mains (8) inoculated portions of leaves of *Zea mays* L., which were floated on carbohydrate solutions, and was successful in keeping a pure culture of the rust organism, *Puccinia sorghi* Schw., by this method.

Clinton and McCormick (4) placed aeciospores of *Cronartium ribicola* Fisch. de Waldh. from *Pinus strobus* L. on leaves of

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*Ribes nigrum* L in a petri dish and secured infection Later in 1924, the same investigators (5) continued their work, using thirteen genera of rusts with varying degrees of success

The following work was begun in the fall of 1923 and continued throughout the winter and spring following The bean rust organism, *Uromyces appendiculatus* Fries, was used in all of the experiments For the original material the writer is indebted to Doctor F D. Fromme of the Virginia Experiment Station and to Doctor E B Mains of the Purdue Experiment Station The work was carried on under the direction of Doctor C. H Kauffman, to whom I am indebted for suggestions and helpful criticism.

The object of the experiments has been to observe the physiological reactions of the parasite when grown on leaves or portions of leaves detached from the host and floated on solutions in petri dishes Such a method of culture if perfected will serve as a means for understanding better the relation of the fungus to the host and the food-supply, and, perhaps ultimately lead to the culturing of the rusts under purely saprophytic conditions To this end much has to be accomplished in the way of technique and the study of the food relations of the fungus.

## EXPERIMENTAL

Bean plants were cultivated in the greenhouse and inoculated so as to insure a stock supply for the petri dish work The varieties of bean, Kentucky Wonder and Tennessee Green Pod, were used in all of the work, since they have been shown by Fromme and Wingard (7) to be the most susceptible.

The method used in inoculating the potted plants with rust was the same as has been employed by the various investigators, namely, that of making a spore suspension in distilled water and spraying them by means of a No. 16 De Vilbiss atomizer, after which the plants were placed in a moist chamber for a period of forty-eight hours at a temperature of 18 to 20 degrees Centigrade At the end of this time the plants were removed from the moist chamber and placed on the greenhouse benches.

The method used in the dish culture was similar to that used by Mains (8) in his work with *Puccinia sorghi*. Leaves, or portions of leaves, were floated on solutions in petri dishes and then infected by applying the inoculum either by means of spraying or with a scalpel or brush of camel's hair The latter method insures a greater amount of infection, but, since uniform infecttion was desirable, the spray method was employed in all of the experiments.

To minimize the amount of contamination in the cultures due to extraneous fungi, extreme care must be exercised in preparing the dishes and in applying the inoculum The same precision of technique must be employed that one would use in any careful mycological culture work

The dishes to be used were first sterilized, after which the sterilized solution was poured into them The amount of solution used is just enough to insure the free floating of the leaf Too much solution is very apt to splash over the sides of the dish and thus afford a means of entrance for bacteria The leaves to be used were carefully washed in sterile, distilled water and placed on the solution in the dishes The atomizer was sterilized and filled with sterile distilled water If a flamed scalpel is used in transferring the spores from the center of the individual uredinial pustules to the water in the atomizer, there is slight danger of contamination from this source During the process of atomizing, the dish cover should not be completely removed for any longer time than is absolutely necessary

Various nutrients were tried in the solutions upon which to float the leaves and it was found that a five per cent sucrose solution gave the best results It was found that not only did the sucrose solution afford the best nutrient to the host leaf but apparently proved to be a relatively poor medium for contaminating bacteria and fungi

Among the various nutrients tried were glucose, levulose, starch, maltose, raffinose, asparagin, sucrose and peptone Distilled water by itself was also used in the work

In storing the dishes after inoculation it was found advisable to use a somewhat different procedure for the dishes containing the sucrose solution than for those containing the distilled water In the former, since the leaves obtained their carbohydrates directly from the solution, it was not necessary that they be placed in the light However, in order to keep contamination low the dishes were placed in the greenhouse under a framework partially covered with black paper In the case of the distilled water cultures, the nourishment obtained by the fungus came from the products of photosynthesis carried on in the dish, this necessitated placing the leaf in a lighted place Repeated trials, however, showed that direct sunlight scalded the leaves very badly. A plan was devised whereby the dishes were placed on the bench of the greenhouse behind a screen of white paper This prevented scalding and at the same time gave the leaf enough light to carry on the photosynthetic processes With this method it is possible to keep the leaf in a living condition for a long period of time. Bean leaves have been kept floating for two months before showing evidences of decomposition In some instances where the leaves were floated on sugar solution, rootlets developed from the petiole and sometimes attained a length of ten centimeters In several cases where portions of stems, taken from immediately below the point of attachment of the cotyledons, were floated on sugar solution, rows of rootlets developed and attained a length of several centimeters before being checked and killed by contamination in the solution

## CONDITIONS FOR INFECTION AND PUSTULE FORMATION

Twenty dishes were used in the first experiment, ten of which contained young primordial leaves from healthy plants floated on a five per cent sucrose solution. The other ten likewise contained healthy leaves, but in this case they were floated on distilled water

On the fifth day after inoculation the leaves in the dishes containing the sugar solution showed light-colored areas scattered over the blade On the sixth day, uredinial pustules broke through on both surfaces of the leaves Fromme and Wingard (7) in their work on the bean rust have found that the sori do not always extend through to both surfaces of the leaf. In all of the cultures made in dishes it has been found that, without exception, the sorus extends through to both surfaces regardless of the surface which was inoculated

On the seventh day after inoculation, the pustules became visible on the leaves which were floated on the distilled water, and by the end of the eighth day had broken through These pustules were smaller and much paler than those formed on the leaves in sugar solution

When the time of incubation in the dish cultures is compared with that of potted plants in the greenhouse, it is evident that the former method lessens the period by at least two days in the case of the sugar solution Plants in the greenhouse show an incubation time of from seven to thirteen days depending on the susceptibility of the host and environmental conditions Also it was observed that the amount of infection was increased over that of the potted host plants

The size of the pustules and the absence of the characteristic brown pigment in the spores produced on the leaves in the distilled water led to the belief that perhaps the viability and the infecting ability of the spores had been lessened To determine this a series of experiments were run for both germination and infection

Spores were taken from both the leaves on the sugar solution and the distilled water and placed in hanging drops on the under side of petri-dish covers Results showed that the spores taken from the former possessed the same degree of germinating ability as those taken from the latter In several trials no differences could be noted

To test the infecting power of these spores, eight potted plants were inoculated, four of them with spores taken from the leaves in the distilled water and four with spores taken from the leaves in sugar solution At the end of eight days the uredinial pustules appeared on the leaves of all eight plants, the degree of infection being the same in all cases

In addition, twelve dishes were arranged, six containing leaves floated on distilled water, and six on sugar solution These were inoculated in the usual manner, three of the leaves of the former, with spores taken from the leaves bearing the normal pustules and three with the spores from the pale, almost colorless pustules The six dishes containing the leaves on the sugar solution were treated in the same manner At the end of six days all of the leaves on the sugar solution showed the characteristic uredinial pustules, the spores of which were pigmented in the usual manner On the eighth day the leaves on the distilled water also showed evidence of infection, but in this case the pustules were of the small and light-colored variety This shows that the source of the inoculum exerted no effect on the degree of infection produced It does suggest, however, that the amount of food present in the host during incubation of the fungus, was a contributing factor to the size of the pustules and the amount of pigmentation of the spores produced Such spores, however, though clearly exhibiting the effects of an apparent paucity of food in the host which produced them, were not affected in their germinating ability or their infecting powers when placed on susceptible and well-nourished hosts Ward (11) in his work on the rusts of Bromes came to very much the same conclusions In his experiments, in which he grew plants in water cultures to show the effect of mineral starvation on the development of the rust parasite, he draws the following conclusion "Mineral starvation makes itself felt quantitatively in the number of uredinia produced on the host," and also "Spores even when reared on starved seedlings are capable of normal germination and infection when placed on leaves of other normal seedlings"

Stakman and Levine (10), while working on the effect of ecological factors on the morphology of the urediniospores of *Puccinia graminis* Pers, make the following observation "Adverse environmental conditions unfavorable for the host are also unfavorable for the parasite, affecting the virulence and spore size of the latter" They also determined the effect of temperature, light, moisture, excess of nitrogenous fertilizers, and age of the host, on the size of the spores, and found in some rusts that such conditions did exert an influence They also found, however, that "As soon as the unfavorable factors are removed the fungus resumes its normal functions and regains its original structure." The results of the writer seem to verify this

Since infection occurred readily through the use of whole leaves floated either on sugar solution or distilled water, it was next in order to determine to what extent infection could be obtained if the leaves were cut into very small pieces

Eight leaves were placed in dishes, four of which contained distilled water, and the other four, sugar solution. The leaves were then cut into small portions, averaging about five millimeters square, and sprayed with the spore suspension

On the eighth day after inoculation the portions of leaves on the sugar solutions showed infection. About ten per cent of the pieces bore the uredinial pustules, which averaged about two to a piece Two days later, the pieces of leaves on the distilled water showed a slight infection Three or four portions in each dish contained the uredinia, and it was noted that in all cases it was the portions of leaf that contained the larger veins that possessed the pustules In these the pustules were formed adjacent to the veins

Experiments similar to these outlined above were tried except that the dishes were placed in the dark during incubation In the case of those portions on sugar solution, the amount of infection was about the same in the dark as in the light. In the case of the distilled water, however, no infection was secured in the dark

De Bary (1), in his series of investigations on the rust, *Uromyces appendiculatus* on *Faba vulgaris* (this is the *Uromyces fabae* De Bary of today), found that the surface of the leaf receiving the greater amount of light will produce the sori in advance of the surface receiving less light He conducted a series of experiments and found that if he inoculated the plant and then exposed one surface or the other of the leaf to the light during the period of incubation, that surface which had been exposed would produce the uredinial pustules sooner than the other He also found that in this rust eventually the sori would extend through to both surfaces

Since all the factors concerned in an experiment like this can be easily controlled by the petri-dish method of culture, experiments were set up to determine whether the same results could be obtained with the rust with which the writer was working.

Sixteen dishes were used for the first trial Young leaves were placed in the dishes, eight of which had the dorsal surface uppermost while the remaining eight had the surfaces reversed Each dish contained distilled water on which the leaves were floated During incubation, four of the dishes containing the leaves with the dorsal surface up, were exposed to normal light conditions The other four were placed so that they would receive twenty-four hours of light each day The dishes with the leaves in the reversed position were apportioned in a like manner A one-hundred-watt nitrogen light was used to supply the artificial illumination It was suspended about three feet above the dishes. During the day all sixteen dishes were exposed to daylight From sunset until eight o'clock A M the artificial light was used for these dishes The dishes were all inserted in openings cut in black paper which surrounded them and thus prevented diffusion of light from the sides

On the seventh day after inoculation, uredinial pustules appeared on those leaves which had the dorsal surfaces uppermost and which had been exposed to continuous light The following day the uredinia appeared on those leaves which had been exposed to normal light conditions and which had the dorsal surface uppermost On the ninth and eleventh days the leaves with the ventral surfaces uppermost showed the pustules in the same order in which those of the other leaves appeared

Examination and counts disclosed the fact that in all the cases the pustules extended entirely through the leaf It was observed, however, that in all of the leaves the pustules first broke through the surface which had been exposed to the light In each case the uredinia were noticeable about one day in advance of those on the under side, regardless of whether the dorsal or ventral surface was up Sections cut through the leaves and treated with chloral-hydrate and iodine showed that in each case where the ventral surface received the light, after the spores had been sprayed upon it, there were a great number of abortive uredinia which had never broken through the surface of the leaf. As a result of this, leaves placed in their normal position, i.e. with the dorsal surface uppermost, always showed a heavier infection than the ones with the surfaces reversed This presents an interesting situation and might be explained in the following manner In the bean leaf the palisade parenchyma is found on the dorsal side and in this the greater amount of food is synthesized This being the case, when the leaf is placed so that the palisade tissue is exposed to the light, more food should be manufactured On the other hand, however, there are seven times as many stomata on the ventral surface as there are on the dorsal, so that, when the leaves are placed so that the spores are sown on the ventral surface, there are seven times as many points of entrance for the fungus This should result in greater infection It is evident that two factors enter into the matter of the amount of infection, the number of germ tubes that enter the leaf, and the nourishment received by the fungus after once gaining entrance

Stakman and Levine (10) and Marshall Ward (11) have shown that the vigor of the fungus is dependent on the vigor of the host, so that in the leaf where there is an abundance of food we should expect to find greater sporulation than in a leaf where there is a scarcity of food, even though many more germ tubes enter in the later case These were the conditions present in the two sets of leaves Even though many more germ tubes penetrated the leaf in the case where the leaves were inoculated from the ventral surface, shortage of food limited the development of the fungus.

While the experiment verifies the results of De Bary, it also shows very clearly an additional influence of light on the development of the rust

Fromme (6), working with *Puccinia coronata* Corda, and Mains (8), with *Puccinia coronata* and *Puccinia sorghi*, have shown that when *Avena sativa* L. and *Zea mays* are inoculated with *Puccinia coronata* and *Puccinia sorghi* respectively, and placed in a dark room during a portion of the incubation period, the time necessary for sporulation is increased approximately in direct proportion to the time that the host plants were left in the dark. From this they concluded that it is probable that the rust is dependent on some transition products of photosynthesis for its nourishment.

The experiment of the writer shows clearly that if the hours of light are increased over the normal during incubation, the time of sporulation is hastened In the case of the leaves which were subjected to continuous light the incubation time was shortened by twenty-four hours This makes the time of incubation for leaves floated on distilled water with continuous light about the same as for leaves floated on sugar solution.

### CONDITIONS FOR TELIOSPORE FORMATION

In the experiments thus far mentioned nothing has been said concerning the production of urediniospores as against teliospore formation Certain results had been noted, but it was thought advisable to include them under the one head

Various investigators have from time to time asserted what was in their opinion the answer to the phenomenon of teliospore formation. The writer will not attempt at this time to go into an historical review of the subject, but suffice it to say that among the various causes presented have been moisture, temperature, humidity, age of host, mechanical injury of the host, fungus constitution, and degree of susceptibility of the host Since the bean rust organism is one that produces urediniospores and teliospores in abundance depending on certain circumstances, it lent itself readily to such a study.

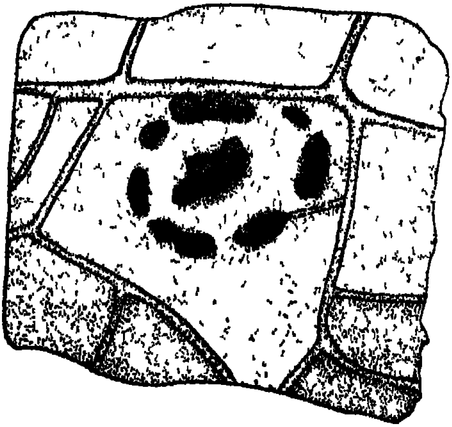

FIG 6 Portion of bean leaf from sucrose solution showing primary and secondary sori with teliospores formed in secondary sori only

Among the first experiments it had been noticed that there always existed a difference in the production of teliospores on the leaves on the sugar solution and those on the distilled water.

In the former case, the secondary uredinia nearly always formed in concentric circles about the primary ones (Fig 6), and in some cases tertiary pustules were formed about the secondary ones (Fig. 7) When teliospores appeared they were always found in the secondary or tertiary pustules, never in the primary

On the other hand, when the leaves were floated on distilled water, teliospores frequently make their appearance four or five days after the first appearance of the uredinial pustules In these cases the teliospores were found interspersed with the urediniospores in the primary sori (Fig 8) and scarcely ever were any secondary sori formed Frequent trials were made in comparing the two sets of conditions and in all cases the results were the same

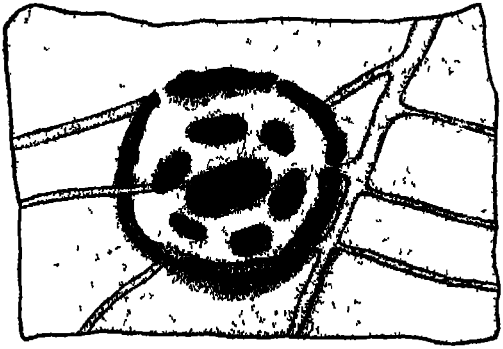

FIG 7 Portion of bean leaf from sucrose solution showing primary, secondary and tertiary sori

In view of the fact that the teliospores seemed to appear first in the leaves on the distilled water, a series of experiments were set up to determine the effect that the addition or subtraction of the carbohydrate would have on the telia production

For the first experiment ten dishes were prepared having the leaves of the bean floated on distilled water, another ten were arranged with the leaves floated on the sugar solution The leaves in all of the dishes were inoculated in the same manner

Six days after inoculation, when the uredinial pustules were just beginning to appear, five of the dishes containing the water were emptied and a five per cent sugar solution added. Likewise five of the dishes containing the sugar solution were emptied, thoroughly rinsed with distilled water, and water was added They were then set aside for another week. For convenience the sets of dishes will be referred to as follows The set which contained the water continuously will be designated as *A*, the set to which the water was added later will be *AA*, the set which contained the sugar during the entire experiment will be *B;* and the set to which the sugar was added will be *BB*

A week later, or thirteen days after inoculation, the cultures were examined with the following results Cultures *A* showed a fair amount of infection with the sori having the characteristic pale color. No secondary pustules had been formed and the leaves were in a good state of preservation, retaining their normal green color Examination showed that the primary sori contained teliospores interspersed with the urediniospores Cultures *B* showed a vigorous growth of the rust evidenced by the numerous uredinia There was an abundance of both primary and secondary pustules The leaves had begun to fade and, with the exception of the regions around the sori, were lighter than normal. *AA*, in which the water replaced the sugar, showed a good infection, almost as plentiful in primary sori as *B*, but with very few secondary ones The leaves were faded and bore evidence of the heavy drain upon the food-supply Examination showed that the secondary pustules were made up of an almost pure production of teliospores The primary pustules, however, showed only urediniospores. *BB*, in which the sugar had replaced the water, showed the best and most luxuriant growth of all The number of sori exceeded even those of *B*, which had been on the sugar solution continuously.

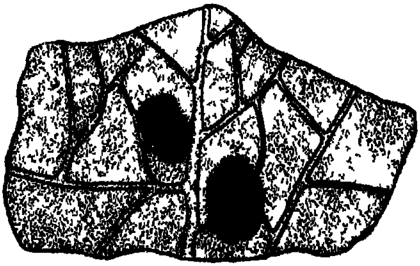

FIG 8. Portion of leaf from distilled water with teliospores formed in primary sori

A week later, or twenty days after inoculation, another examination was made of the cultures *A* showed the smallest amount of infection The pustules were still very small and in only a few instances had secondary sori been formed Microscopical examination revealed that the primary pustules contained an almost pure production of teliospores The leaves were still quite green and showed less ill effect from the presence of the fungus than did any of the other leaves *B* showed death of most of the leaves, and the secondary and tertiary sori were found to contain many teliospores *AA* showed no further development The secondary pustules were almost purely telial in composition as were also the primary ones *BB* displayed further blanching of the leaves with the formation of teliospores in the secondary and tertiary pustules

To attempt a full interpretation of these results would involve a long and difficult explanation Since, however, the appearance of the teliospores seems to bear a distinct relationship to the presence or absence of the sugar solution, a brief discussion will be attempted

It is safe to assume that when the leaves were inoculated practically the same number of germ tubes entered all the leaves In *A*, which was on the distilled water, the mycelia resulting from the successful entrance of the germ tubes were not all able to develop to the point of sporulation because of the scarcity of food, and as a result, only a few small pustules broke through In *BB* the same condition was present to the time of the addition of the sugar solution When this was added the many mycelia which till this time had been lying dormant in the leaf tissue began growth rapidly and the result was a luxuriant production of uredinia In *B*, which contained the sugar continuously, the fungus developed so rapidly and in such abundance that at the time of sporulation the cells of the host were robbed of their food and eventually killed In *AA*, which contained the sugar to the time of spore formation, the subtraction of the sugar at this critical period caused a partial cessation of the fungus activity as well as that of the host, with the result that teliospores were formed immediately.

It is interesting to note that *B*, which contained the sugar during the entire experiment, did not show as great spore production as *BB*, which contained sugar only during the latter part of incubation  This might be explained in the following manner  The sudden addition of a rich supply of food to the leaf at a period when the leaf, and consequently the fungus, was partially starved stimulated the growth of the fungus to a point which was even greater than that of the fungus which had a continuous and constant food concentration

In summation, one can scarcely fail to be impressed by the coincidence that the disappearance of food was apparently the signal for the formation of teliospores  The experiment was repeated several times and practically the same results were obtained each time  In this first report on the reactions of this rust, it is to be emphasized, however, that no final conclusions should be drawn from the results obtained  Rather it should be remembered that rarely does one cause act alone in such a complicated relation as that of a rust and its host.

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# CULTURAL LIFE-HISTORIES OF CERTAIN SPECIES OF EUTYPELLA, DIATRYPELLA AND CRYPTOVALSA*

LEWIS E WEHMEYER

THE three genera here considered are included in the "Allantosphaeriaceen" of Von Hohnel (4), who has shown that this group has certain correlated characters in common In the older classifications Eutypella and Cryptovalsa were placed in the Valsaceae and by some writers (Nitschke and Winter) as subgenera of the genus Valsa, while Diatrypella was placed in the Diatrypaceae Such a separation was entirely artificial All three of these genera have a similiar stromatic structure, yellowish- to brownish-hyaline, allantoid ascospores, long-stalked asci, arranged in a definite hymenial layer, sulcate ostioles, and filiform, hyaline, curved or hamate conidia The genus Valsa shows none of these characters The related genera Diatrype, Quaternaria, Cryptosphaeria, Eutypa, etc, on the other hand, do show these characters The genera Diatrypella and Cryptovalsa differ from Eutypella in the possession of polysporous asci The difference in stromatic configuration, however, occupies the same range of variation in Eutypella that it does in the two polysporous genera The following study of the development and life-histories of these forms was made in an attempt to find further differences and similarities which would suggest relationships within this group.

## EUTYPELLA TUMIDA (E. & E.), comb nov

Material of this species was collected on twigs of *Ulmus americana* L. near Ypsilanti, Michigan These specimens agree with Ellis's *N A F.*, 2d Ser, No 2525 of *Diatrype Daldiniana* de Not, which he later made the basis of his *Diatrype tumida* E & E (2) The specimen of these exsiccatti is an extreme form of the species, with an effused well-developed entostroma It does not belong in the genus Diatrype, as it lacks the well-developed deciduous ectostroma and widely erumpent entostromatic disc of that genus It furthermore has the stromatic development and imperfect stage characteristic of the genus Eutypella. It is therefore placed in this genus as **Eutypella tumida** (E. & E), comb nov

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* Paper from the Department of Botany of the University of Michigan, No 230

The stromata of *E tumida* are widely variable (Pl XVIII, Figures 1, 2). A knowledge of the development of the stroma is necessary for an interpretation of these variations. Since this species offers excellent material for the study of this type of variation, which is common not only in the genus Eutypella, but in many other stromatic forms as well, it will be worth while to go into some detail as to this process.

The first indication of the origin of a stroma, under natural conditions, is the cutting off of areas of the bark cortex by the formation of narrow bounding zones of blackened tissue This tissue consists, in this species, of a matted growth of fine fungous hyphae with blackened walls, which blacken, and more or less fuse with, the enclosed bark cells The position of these darkened zones in the bark defines the final configuration of the entostromatic area These zones may enclose small areas in which a single cluster of perithecia develop, or they may enclose very extensive areas including hundreds of perithecial clusters In either case the bark areas within the bounding zone are richly interspersed with a hyaline entostromatic mycelium, which gives a lighter color to these areas. About the same time that these bounding zones appear, small mats of ectostromatic mycelium are formed at various points within these areas on the surface of the bark. Where only a single ectostroma, with a single group of perithecia beneath, develops in such an area, a true isolated stroma results Where more extensive regions of bark tissue are enclosed, a number of such ectostromatic cushions are produced, beneath each of which there is usually developed a cluster of perithecia Now in these extended areas, the number and proximity of these ectostromata formed, the number of perithecia arising beneath each ectostroma, and the amount of ectostromatic mycelium produced in these areas, particularly about the perithecia, give rise to the large number of variations in the superficial appearance of the stroma From this type of development, it can be seen that the type of configuration usually spoken of as 'confluent' stromata is not one in which the stromata become confluent by an extension of area, but is really an effused entostroma within which a number of ectostromatic cushions and their associated perithecial clusters are formed, and may often be separately erumpent

The asci of this species are clavate and long-stipitate, are born in a definite hymenial layer, and measure (p sp ) 31–50 × 5 8 μ The spores are biseriate in the ascus, allantoid and brownish-hyaline, and measure 9–13 × 2-2 5 μ

Sprays of ascospores from the perithecia on Ulmus twigs were made on December 8, 1923, and were germinating twenty-four hours later The spores had swollen greatly, and measured 21–24 × 8 μ They had pushed out one or two large germ tubes 5 μ in diameter, from which numerous smaller branches, 2–3 μ in diameter, were produced

On January 3, 1924, a single ascospore culture on Leonian's agar (5), from December 9, showed numerous, minute, hemispherical, stromatic bodies on the surface of the agar These were exuding orange-colored spore-horns Several similar fruit bodies were also found on a culture on 6 per cent oatmeal agar On this medium they were somewhat larger and buried in a superficial cottony growth of mycelium These stromata were as much as 1 mm in diameter and were composed of a mass of hyaline hyphae, within which were formed a number of conidial locules. These locules had rather definite walls of dark-colored hyphae The conidia were cut off from a peripheral hymenium of filiform conidiophores, they were filiform, hamate and hyaline, and measured 16–18 5 × 5 μ (Figure 3). The numerous locules became confluent at maturity, forming irregular chambers

On January 9, 1924, a sterile twig of *Ulmus americana* L was inoculated from a single spore culture. Superficial whitish stromata were formed upon this twig, and it was examined on October 7 Conidial stromata were then present, some of which were exuding orange-colored spore-horns The growth on Ulmus twigs was chiefly ectostromatic, and the locules were formed in the stromatic cushions which arose between the periderm and the bark These locules were numerous and irregularly confluent They were also found, occasionally, in the entostromatic tissue of the bark It should be stated here that in culture there is usually an abundant formation of ectostromatic tissue, without any formation of darkened zones within the bark This indicated, to the writer, that one of the reasons for not obtaining perithecial stromata readily in culture is the comparative lack of penetration of the hyphae into the deeper bark tissue, because of the greater concentration of moisture in the surface layers of the bark

On twigs collected in the field, entostromatic pycnidia typical of the genus Eutypella were found in association with the perfect stage These pycnidia consist of numerous labyrinthiform locules imbedded within the bark tissues, and belong in the form-genus Cytosporina The conidia of the pycnidia found in nature, as well as those produced on twigs in culture, were identical with the ones formed on agar

### EUTYPELLA FRAXINICOLA (Cke & Pk) Sacc.

This species, which was collected on *Ulmus americana* near Ann Arbor, Michigan, is similar in appearance and development to *Eutypella tumida* It differs chiefly in the smaller asci and ascospores The entostromatic areas are usually widely effused and are somewhat less differentiated than those of *E tumida.* The ectostromata and perithecial clusters are rather widely spaced, with the result that there appear to be numerous separately erumpent or 'confluent' stromata within each entostromatic area. These perithecial clusters form circular pustules, 5–1.5 mm. in diameter, which are erumpent as a cluster of flattened hemispherical, quadrisulcate, black ostioles The perithecia are spherical or laterally flattened, 320–500 × 260–350 μ The asci are clavate and long-stipitate, and measure (p sp) 26–31 × 4–5 μ The spores are biseriate, allantoid, 1-celled and brownish-hyaline, and measure 7-9 × 2 5 μ

On October 10, 1923, sprays of ascospores were made from the material mentioned The spores were seen to swell somewhat, but no germination took place. The Ulmus twigs were then placed at 0–3° C until October 29, when they were placed in a damp chamber at room temperature, for twenty-four hours On October 30 sprays were again made from these twigs, and twenty-four hours later germination was well advanced The spores had swollen, measuring 13–15 × 4 5 μ, and had thrown out germ tubes, 2–3 μ in diameter, from both ends of the spore

A single ascospore culture on 6 per cent oatmeal agar, made on November 3, formed a superficial cottony growth of mycelium, in which there soon arose numerous minute clumps of blackened hyphae This blackening of the hyphae spread over the entire surface, but no fruit-bodies were formed in the agar cultures

Sterile twigs of *Ulmus americana* were inoculated from a single ascus culture on December 1, 1923 On January 1, 1924, these twigs showed conidial stromata with orange-colored sporehorns These cultures were placed out of doors for three months, and on May 1, 1924, crowded, erumpent stromata were present, beneath which were found perithecial initials In this species, as in *E. tumida*, no darkened zones were formed within the bark, in the twig cultures, even though perithecial initials were formed

In culture both the perithecial and conidial stromata were initiated by the formation of an ectostromatic cushion, which usually formed between the cork cells of the periderm and the phelloderm cells beneath When the cultures were moist, this tissue increased rapidly and formed erumpent stromata, within which conidial locules were sometimes produced Conidial locules were usually formed in masses of entostromatic mycelium within the bark tissues (Figure 4) A number of such locules arose within close proximity of one another, and coalesced to form a labyrinthiform chamber. The conidia were cut off from a hymenium of filiform conidiophores, and were filiform, curved and hyaline, and measured 16–19 × 5 μ (Figure 7). Such entostromatic pycnidia, with similar conidia, were also found associated with the perithecial stage in nature

In the case of the perithecial stroma the ectostroma remains sterile The perithecial initals arise as knots of hyphae in the surface layers of the bark tissue just beneath the ectostromatic disc Within these perithecial initials there can be seen a coil of deeply staining 'Woronin hyphae,' some 2 μ in diameter. These perithecial initials have not been brought to maturity in culture

### CRYPTOVALSA NITSCHKEI Fckl

Material of this species was collected on *Ulmus americana* L, near Ann Arbor, Michigan The fungus appears on the surface of the twig as numerous conical pustules, 3–5 mm in diameter, which are erumpent as minute central discs, composed of 1 to 4 quadrisulcate ostioles, which soon crumble to a misshapen mass. The entostromatic configuration is similar to that of the two preceding species The differentiated entostromatic areas are outlined by a darkened zone which dips to the wood surface There may be one or a number of perithecial clusters included in such an area The perithecia are spherical, 350–400 μ in diameter, have short stout necks, and walls some 40 μ thick The perithecia occur singly or in small groups of two to four These groups are rather widely spaced, forming separately erumpent pustules In thin bark, or on small twigs, the perithecia may be more or less imbedded in the wood The asci are polysporous, clavate and long-stipitate, they have a thickened conical apex and measure (p sp ) 80–95 × 13–15 μ The spores are allantoid, 1-celled and yellow-brown at maturity, and measure 10–16 × 2–2.5 μ

This form agrees with Winter's (10) description of *C Rabenhorstii* Nit Saccardo (7, p 188) considers *C Rabenhorstii* a large-spored form of *C. Nitschkei* Fckl., and this has been followed by Ellis (2) for his American collections.

On October 10, 1923, sprays of ascospores from twigs of Ulmus were made. These spores did not germinate The same twigs were then placed in a cold room at 0–3° C until October 29, when they were removed to a damp chamber at room temperature for twenty-four hours. On October 30, sprays were again made, and twenty-four hours later the spores were germinating. The spores had swollen greatly, and measured 20–30 × 4–5 μ They had pushed out a number of germ tubes 3–4 μ in diameter, from both the ends and sides of the spores Sprays made from the same twigs, but different perithecia, the following day, failed to germinate.

A single ascus culture made on 6 per cent oatmeal agar on April 8, 1924, produced a white surface mat of mycelium This culture was kept over the summer in a cold room at 0–3° C When they were examined on October 8, there were found numerous minute black flecks within the surface mat of mycelium Sections showed that these contained conidial locules These locules were spherical to ellipsoidal, and were surrounded by a wide zone of heavily blackened hyphae, forming a wall-like boundary. The conidia were born on cylindrical conidiophores, and were filiform, hamate and hyaline, and measured 21–40 × 1 μ (Figure 8)

On December 11, 1923, a sterile twig of *Ulmus americana* L. was inoculated from a single ascospore culture Stromata appeared on this twig a few weeks later, and were soon thickly scattered over its entire surface These stromata were 5–2 mm in diameter, and yellow when they broke through the periderm, but soon became blackened. No darkened zones were formed in the bark of the twigs in culture These ectostromata developed between the periderm and bark, and often contained one or more conidial locules, which soon coalesced to form a labyrinthiform chamber. There was often a rich development of entostromatic mycelium in the surface bark layers below these ectostromata. These two adjacent mycelial developments formed a homogeneous tissue, so that the ectostroma often seemed partially imbedded within the bark. The conidial locules were often partially imbedded in this entostromatic tissue (Figure 5) The conidia were formed on short cylindrical conidiophores, and were 1-celled, hyaline, long-filiform and strongly curved or hamate, and measured 26–34 × 1 μ. Only a very few perithecial initials were seen on the twigs in culture. In nature small patches of ectostroma are formed here and there over the surface of the entostromatic bark areas, but the perithecia do not always develop beneath these ectostromata The perithecial necks themselves often push open the periderm This, again, indicates that, although the perithecial clusters are separately erumpent, we are dealing here with an effused entostroma in which the perithecia have not as yet become definitely oriented beneath the ectostromata

### CRYPTOVALSA SP

The species here considered is very similar to *C Nitschkei* in structure, and was also collected on twigs of *Ulmus americana* L near Ann Arbor, Michigan It differs from *C Nitschkei* chiefly in the narrower asci and smaller ascospores The stromata appear on the surface as scattered or confluent circular pustules, 5–1 mm. in diameter The entostroma is effused, as in *C Nitschkei*, containing a number of perithecial clusters The perithecia are spherical, 2 to 10 in a group and 300–400 μ in diameter The asci are polysporous and long-stipitate and measure (p sp ) 106 × 8–10 μ The spores are crowded, allantoid, yellowish-hyaline, and measure 6–8 × 1 5 μ

On October 10, 1923, sprays of ascospores were made from suspensions both in distilled water, and in Leonian's nutrient solution (5) Germination took place very slowly The same twigs were then placed in a cold room until October 29, when they were removed for one day to a damp chamber at room temperature. On October 30, sprays were again made, and twenty-four hours later germination had begun. The spores had swollen greatly, being 16 × 4 μ, and had pushed out one or two germ tubes, 3–4 μ in diameter, from each end. A single ascospore culture on 6 per cent oatmeal agar produced a matted surface growth of mycelium, but no fruit-bodies

On November 15, a sterile twig of *Acer saccharum* Marsh was inoculated from a single ascus culture. Numerous, erumpent, hemispherical stromata, .1–1 mm. in diameter, were formed upon this twig These stromata were usually found in confluent lines, on account of the configuration of the bark They were white and did not show the yellowish coloration noted in *C Nitschkei* These stromata were ectostromatic and formed on the bark surface or somewhat sunken in the surface bark layers Labyrinthiform conidial locules were formed within this tissue Large numbers of conidia almost identical with those of *C Nitschkei* were formed in these locules and were emitted as yellowish- to orange-colored spore-horns They were filiform, strongly curved and hyaline, and measured 26–40 × 1 μ No darkened zone was formed in the bark, in culture A few very young perithecial primordia were seen beneath some of the sterile ectostromata

### DIATRYPELLA QUERCINA (PERS ) NIT f Crataegi

This species was collected on *Crataegus sp* near Ann Arbor, Michigan These specimens agree perfectly with Ellis, *N A F*, 2d Ser, No 2747 of *Diatrypella quercina* (Pers ) Nit forma *Crataegi* The specimens of these exsicatti contain old stromata which are black, and do not show the yellow-green coloration of the young stromata

The stromata are usually thickly scattered over the twig, are conical-pustulate and erumpent through a lateral split in the periderm, they appear as small clusters of black, hemispherical, sulcate ostioles The ectostromatic disc, when young, is a yellowish-green, but becomes blackened in age The slightly differentiated entostromatic areas are outlined by a blackened zone, and are usually effused, enclosing several perithecial clusters The asci are polysporous, clavate and long-stipitate, and measure (p sp ) 100–110 × 9–12 μ, and have a thickened apical wall. The spores are allantoid, 1-celled and brownish-hyaline, and measure 8–10 (12) × 2–2 5 μ

Sprays of ascospores from Crataegus twigs were made on October 15, 1923. No germination took place The addition of a nutrient solution to the spore suspension and removal to a cold room failed to stimulate germination. The twigs were then placed at 0–3° C. until November 2, when they were put in a damp chamber at room temperature On November 9 sprays were again made Twenty-four hours later the spores had swollen to a size of 18–19 × 4–5 $\mu$, and were pushing out 2–3 germ tubes 3–4 $\mu$ in diameter

Single ascus cultures on 6 per cent oatmeal agar formed no fruit-bodies, but merely produced a superficial greyish mycelium and blackened the surface of the agar

Inoculations on sterile twigs of *Crataegus sp*, from single ascus cultures, were made on January 3, 1924 About February 5 these cultures began to show superficial stromata, 2 8 mm in diameter, which soon appeared thickly scattered over the twig surfaces

In culture the growth was chiefly ectostromatic, and no darkened zone was produced in the bark The stromata were initiated here, as in many other forms, as a mat of ectostromatic hyphae just beneath the periderm This tissue, in this species, is a bright yellow-green and grows upward as a cone of parallel hyphae, which bursts open the periderm, and forms the erumpent disc When well developed, this yellow-green stroma takes on a spherical shape, and is seen to be rather deeply imbedded in the surface bark tissues No perithecial initials were seen in culture, but on twigs collected in the field such initials were found developing both beneath and within such well-developed stromata (Figure 9). In the latter case the perithecia are apparently developing within the ectostroma. The interpretation depends upon the development of this tissue within the bark The sharp outline and purely fungous character of the tissue point to a more or less mechanical invasion of the bark tissues by the ectostroma The entostroma is often richly developed about the perithecia, however, and these imbedded stromata may arise by an absorption of the bark cells and a fusion of these ectostromatic and entostromatic tissues, as noted in *Cryptovalsa Nitschkei*. In this case the perithecia would have an entostromatic origin.

The imperfect stage, in culture, was formed as an irregular locule in the ectostroma, often in the erumpent superficial part of this tissue Such locules were found occasionally in the surface bark layers also (Figure 10) These locules were lined with a hymenium of filiform hyaline conidiophores, measuring 35–40 ×

1 5–2 μ. The conidia were 1-celled, filiform, hyaline and hamate or curved, and measured 30–45 × 1 μ (Figure 12).

### DIATRYPELLA FAVACEA (FR ) NIT

This species was collected on various hosts from different localities, including material on *Alnus tenuifolia* Nutt. from Copeland, Idaho, on *Betula pumila* L and *Prunus sp* from Ann Arbor, Michigan, on *Betula lutea* Michx from Ann Arbor and from the Catskill Mts , N Y The stromata are usually thickly scattered over large areas, they are hemispherical to laterally elongated and pustulate, they measure 2–5 × 1 5–2 5 mm , and are 1–1 5 mm in height They are erumpent through the closely adherent epidermis as a whitish pulverulent, circular to fusoid disc, containing 4–12 depressed, hemispherical, quadrisulcate ostioles The stromata in this species are of the isolated type, the darkened zone, which penetrates to the wood, encloses a light-colored entostromatic area, which contains only one cluster of perithecia The perithecia are large, spherical or irregular in shape, they have walls 20–25 μ in thickness and measure 800–1100 × 400–800 μ The asci are polysporous, clavate, often variously swollen and long-stipitate, they have a long, thickened, blunt, conical apex, and measure (p sp ) 78–106 × 8–15 μ The spores, which are variously distributed in the ascus, are allantoid, yellowish-hyaline and 1-celled, and measure 5–6 5 × 1–1 5 μ

There is some variation in this species on different hosts On Alnus, Prunus and *Betula pumila* the stromata are circular in outline, while on *Betula lutea* they are larger and laterally elongated This is probably on account of the configuration of the host bark, however On Alnus the asci measured 79–92 × 13 15 μ, on *Betula pumila*, 79–92 × 9–10 μ, and on *Betula lutea*, 92–106 × 8–13 μ The asci swell greatly at maturity, however, often forming lateral protrusions, and the spores may be variously distributed, either crowded in the tip, or extending far into the stipe, so that measurements (p sp ) may vary a great deal

Sprays of ascospores of this species, from two different sources, were made on March 1, 1923. The first was from twigs of *Alnus tenuifolia* from Idaho, and the second from twigs of *Betula pumila*, from Ann Arbor, Michigan The growth in both cases was identical The spores of the Idaho specimen germinated slowly, and pushed out a single germ tube from each end of the spore, but only after four days in sterile distilled water The spores of the Ann Arbor specimen germinated within forty-eight hours and formed 3–4 germ tubes from the sides and ends of the spore This difference in germination may be accounted for by the fact that the Idaho material had been thoroughly dried out, while that from Ann Arbor was fresh from the field.

On 6 per cent oatmeal agar both strains gave an even, white, superficial, cottony growth No fruit-bodies were obtained in agar cultures

On May 28 transfers from single ascus cultures were made to sterile twigs of *Betula alba* L, which were kept at 0–3° C When returned to room temperature, on September 18, these twigs had developed a superficial cottony growth, and after a few weeks at room temperature there appeared hemispherical mycelial masses, which took on an orange tint In these first cultures the growth was mostly superficial, and the stromata originated within the periderm The mycelium grew between the layers of the periderm cells and disrupted this tissue, forming dome-shaped masses Conidial formation then took place within this mass of hyphae, and continued until the entire tissue was used up in spore formation There then remained only an orange-colored mass of conidia, in which there were imbedded the remnants of the periderm cells The conidia were long filiform, 1-celled and strongly curved, and measured 18–40 × 1–1 5 μ (Figure 11) No dark zone was formed within the bark of these twigs Brefeld (1) obtained cushion-like stromata of *D favacea* in culture, but failed to obtain conidia The Tulasnes (8) give the conidia of this species as curved and 40 μ in length Fuisting (3) mentions a second type of conidia for this species, which he gives as being 1-celled, hyaline and allantoid, and measuring 4–6 × 1 μ. The writer has seen no such conidia in any of his cultures.

A later culture of the Ann Arbor strain on *Betula alba* produced more normal stromata In this case differentiated entostromatic areas with a darkened marginal zone were formed Examinations of these stromata, as well as young stromata from the field, showed that the ectostroma and entostroma are not distinctly differentiated in this species The ectostroma originates as a small mat of hyphae on the bark surface, which sends hyphae upwards between the periderm layers and separates the cells of this tissue This tissue within the periderm is very strongly developed in culture (Figure 6). Both Füisting (3) and Ruhland (6) have noted this characteristic weak development of the ectostroma, and its penetration of the periderm, in this species At the same time that this ectostromatic development takes place, there is a rich proliferation of entostromatic hyphae within the surface bark layers. These two tissues often become so closely associated that it is difficult to distinguish them This strong development of the entostroma pushes up the periderm and ruptures it at the point weakened by the ectostromatic hyphae Where conidial locules arise in nature, they are formed in the ectostroma or in the well-developed entostroma of the surface bark layers No perithecial initials were found in culture, but in nature these develop within the entostromatic tissue

## CONCLUSIONS

Superficially, the stromata of the genera Cryptovalsa, Diatrypella, Eutypella, and also Diatrype, are very similar in appearance A study of the development of the species of these genera, however, reveals certain minor differences, which seem to be constant for each genus.

The genus Diatrype, as shown by the work of Füisting (3) and the writer (9) on *Diatrype stigma* (Hoff.) de Not, and of Ruhland (6) on *D disciformis* (Hoff ) Fr, is characterized by a well-developed deciduous ectostroma, which throws off the periderm from the entire surface of the equally well-developed entostroma, which in turn forms the erumpent disc of the mature stroma The imperfect fruit-bodies of this genus are entirely ectostromatic and consist of more or less open cavities within such a stroma.

Both Füisting (3) and Ruhland (6) pointed out that the more conical and less widely erumpent type of stroma, which differentiates most species of Diatrypella from those of Diatrype, is caused by the poorly developed ectostroma of the former genus In each of the four polysporous species herein considered, we have noted the slight development of the ectostromatic tissue, which is usually closely associated with, and often hardly distinct from, a well-developed entostromatic mycelium within the surface bark layers In culture there is a tendency towards a greater development of the ectostromatic tissue As a result of this strongly developed entostroma in the surface bark layers, the pycnidial locules often develop partially within the bark tissues. This type of structure is correlated with the polysporous condition of the asci and is intermediate between those found in the genera Diatrype and Eutypella. The differences between Diatrypella and Cryptovalsa are merely differences of degree, the stromata of Cryptovalsa being more effused in character and less strongly developed The distinction between the two genera is therefore purely arbitrary

The stromata of the genus Eutypella may be either effused, as in the two species herein considered, or it may be isolated, as in the case with *E cerviculata* (Fr ) Sacc , the development of which is described in a forthcoming paper (9) The ectostroma in this genus is not very strongly developed, but is usually sharply differentiated Although conidial locules are sometimes formed in the ectostroma, the imperfect stage of this genus usually consists of numerous separate locules or a single labyrinthiform locule produced within the entostromatic tissues in the bark cortex, and belongs in the form genus Cytosporina

Since each of the three groups just discussed shows a series of species exhibiting all variations from an effused to an isolated type of stroma, and since, at the same time, each group shows characteristic minor variations in development, these groups represent to the writer three separate and parallel lines of stromatic development.

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## EXPLANATION OF PLATE XVIII

FIGS. 1, 2. Variations in the configuration of the perithecial stroma of **Eutypella tumida** (E. & E.), comb. nov.

1. Vertical section showing an effuse, strongly developed and pustulate entostroma with irregularly scattered perithecia, either singly or collectively erumpent.
2. Vertical section showing effuse entostroma, but not so strongly developed, and with the perithecia in small clusters, which are separately pustulate, the perithecia of each cluster collectively erumpent through a separate ectostroma.

FIG. 3. Conidia of *Eutypella tumida* (× 2000).

FIG. 4. Vertical section of conidial locule of *Eutypella fraxinicola* (Cke. & Pk.) Sacc., from culture, showing the overarching layer containing the remains of bark cells, which indicates the entostromatic character of this locule.

FIG. 5. Vertical section of conidial locule of *Cryptovalsa Nitschkei* Fckl., from culture, showing the formation of the locule partially within the ectostromatic cap above, and partially within the entostromatic tissues of the bark below.

FIG. 6. Vertical section of young stroma of *Diatrypella favacea* (Fr.) Nit., from culture, showing a dark marginal line circumscribing an isolated entostromatic area (note that the darkened zone does not penetrate the stone cell area). The ectostromatic mycelium is here formed almost entirely within the heavy periderm.

FIG. 7. Conidia of *Eutypella fraxinicola* (× 2000).

FIG. 8. Conidia of *Cryptovalsa Nitschkei* (× 2000).

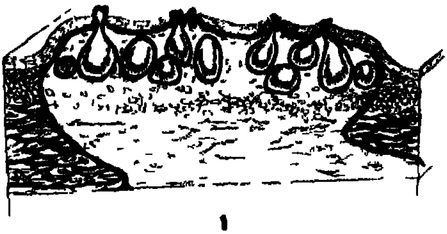
FIG. 9. Vertical section of two confluent stromata of *Diatrypella quercina* (Pers.) Nit. f. *crataegi* E. & E. The marginal zone is here rather faint and indistinct. The perithecia, in some cases, apparently originate in the upper ectostromatic cap, and are often surrounded by this tissue at maturity.

FIG. 10. Vertical section of conidial locule of *Diatrypella quercina* forma *crataegi*, from culture. The locule is, here again formed partially within the ectostroma and partially within the entostroma. The remains of the bark cells can be seen at the sides of the locule, but the apical cap is entirely ectostromatic.

FIG. 11. Conidia of *Diatrypella favacea* (× 2000).

FIG. 12. Conidia of *Diatrypella quercina* f. *crataegi* (× 2000).

# PLATE XVIII



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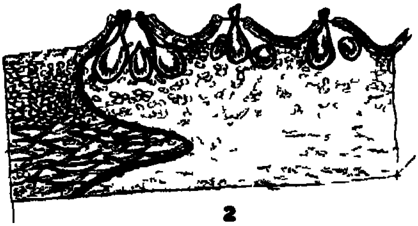

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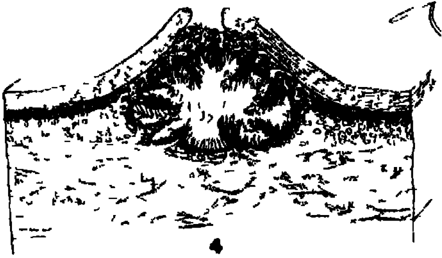

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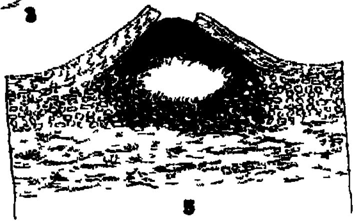

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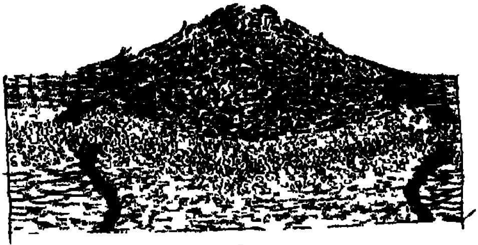

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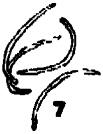

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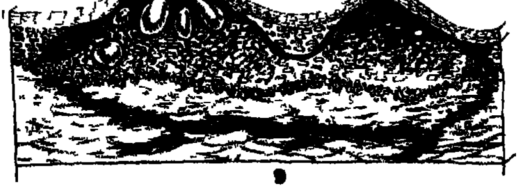

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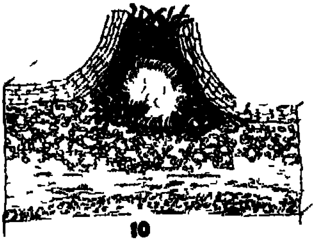

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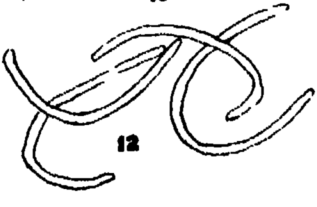

12

# MORPHOLOGY OF THE SEED IN *CLAYTONIA VIRGINICA*

E F WOODCOCK

A STUDY of the morphology of the seed in the closely related families Polygonaceae and Phytolaccaceae was made by the writer (4, 5) to determine if the embryo in the mature seed of these families was, as suggested by Johnson (2, 3), separated from the perisperm by a digestive endosperm Johnson found such a layer present in the seeds of Piperaceae which served to digest and pass food to the embryo

The endosperm was found to occupy the entire storage region in the mature seed of Polygonaceae and the only evidence of endosperm in Phytolaccaceae was a cap of tangentially compressed cells fitting over the hypocotyl end of the embryo There was no evidence of the cap of cells just mentioned serving as a digestive structure, as suggested by Johnson. The writer was also unable to observe any cell contents in the form of fat and aleuron in the endosperm of Phytolaccaceae as stated by Harz (1).

The rather marked difference in the endosperm development in Polygonaceae and Phytolaccaceae from that suggested by Johnson caused the writer to make a study of the conditions in a representative of the closely related family Portulacaceae.

## DESCRIPTION AND DISCUSSION OF THE MORPHOLOGY OF THE SEED

The species *Claytonia virginica* L. was used for study. The various stages of seed development were sectioned with the microtome and stained with Delafield's Haematoxylin.

The laterally compressed ovules are amphitropous, roundish and kidney-shaped (Pl. XIX, Fig. 1). The embryo sac is a long narrow curved structure, occupying a central position and extending about four fifths of the distance around the ovule. The embryo sac is separated from the integuments by four or five layers of nucellus cells The inner integument is made up of two layers of flattened cells, while the cells of the two layers of the outer integument are larger but somewhat similar in shape

The fertilized egg by nuclear and cell division gives rise to a filament of three cells (Fig 1) The two cells nearest to the micropyle, by further growth, develop the suspensor while the remaining cell gives rise to the embryo The cell of the suspensor nearest to the micropyle is about four times the length of the other cell and much vacuolated The embryo sac at this time is lined with a layer of cytoplasm in which are imbedded numerous endosperm nuclei

By the time the embryo has reached the stage shown in Figure 2 marked changes have taken place in the suspensor The cell nearest the micropyle has become much broader in the region next to the embryo while the other suspensor cell is only about half as wide and has undergone several cross divisions (Fig 3) The broadened part of the large suspensor cell is occupied by a large vacuole The cell changes in the embryo have proceeded much as in the typical Bursa embryo At this stage of development (Fig 2), a striking difference is evident in the shape of the cells which make up the outer integument, especially in the region near the chalaza The outer row of integument cells (Fig 6) has become stretched to such an extent that in many cases alternate radial walls have broken loose from their point of attachment to the outer wall of the cell, thus forming large cells whose outer wall is dome-shaped These changes in the cells become less marked in the micropylar region of the integument. The large integument cells become densely filled with a granular material, the composition of which the writer did not determine

It is important to note that in the stage of seed development just described (Fig 2), there is evidence of storage material in the nucellus cells in the form of large, spherical, compound starch grains, of various sizes and closely packed together (Figs 4 and 5)

Those cells making up the hook-like portion of nucellus which is partly encircled by the embryo sac contain the starch grains.

The chalazal region of the nucellus and the region between the embryo sac and the integuments show no starch grains present

As development proceeds the suspensor becomes shrivelled and appears only as a few cell remains At the stage shown in Plate XX, Figure 7, the cotyledons of the embryo have become quite well developed and somewhat spread apart, no plumule being evident at their base No cell formation has appeared in the endosperm, but the number of nuclei has increased to a marked extent, especially in the micropylar portion of the sac The nucellus between the embryo sac and the integuments has become much compressed and there is still no evidence of starch grains in this region The cells of the remaining portion of the nucellus now appear to be filled to capacity with starch grains.

No very marked changes take place in the nucellus during the further growth of the seed except that the tissue between the embryo sac and integuments becomes reduced to compressed cell remains The embryo by further growth comes to occupy most of the embryo sac and to extend almost the entire distance around the periphery of the seed In the mature condition shown in Figures 8 and 9 some very interesting changes from the early stages of development are evident The embryo is now completely surrounded by a layer of cellular endosperm whose cell walls are distorted and whose cell contents consist of disorganized protoplasm Perhaps Johnson had in mind such a layer of endosperm when he made for Polygonaceae and Phytolaccaceae the suggestion cited earlier in this paper, but the cells which make up the layer in Claytonia have none of the characteristics of typical digestive cells About two thirds of the embryo consist of hypocotyl, so that as a result the cotyledons are rather short, and in cross-section (Fig 9) they are nearly semicircular The flat surfaces of the cotyledons are almost in contact and instead of being parallel with the flat surface of the seed they lie at a slight angle as shown in the Figure The mature seeds are brownish-black and somewhat shiny The outer walls of the cells of the outer integument have now become very much thickened (Fig 11) and in surface view appear to have mosaic-like markings (Fig 10), due to the irregularity of the wall thickening. The mature seed also shows a deep indentation in the chalazal region and the remains of the shrivelled funiculus

## SUMMARY AND CONCLUSION

The ovule is a somewhat flattened amphitropous structure, the embryo occupying a curved central position in the nucellus The endosperm becomes cellular at a late stage in seed development, and is evident only as a layer of distorted cells in the mature seed. The early stages of embryo development are quite similar to Bursa, except for the appearance of a large vacuoled cell constituting the micropylar end of the suspensor Early in the development of the seed the cells of the nucellus become filled with compound starch grains, so that as a result the storage region consists of a starchy perisperm

The absence of the digestive layer of endosperm, which Johnson found in Piperaceae, would place Portulacaceae in the same group as Polygonaceae and Phytolaccaceae with respect to the suggestion made by Johnson, which was mentioned earlier in this paper.

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## DESCRIPTION OF PLATES

All figures drawn from median longitudinal sections cut parallel to flat surface of seed, except Figure 9, which is cut at right angles to flat surface. The following abbreviations are used E, embryo, ES, embryo sac; S, suspensor, P, perisperm; T, testa, M, micropyle, F, funiculus, N, nucellus; EN, endosperm, C, cotyledons; OI, outer integument, INI, inner integument; INS, integuments, H, hypocotyl.

### PLATE XIX

Fig 1 Young ovule, showing amphitropous form, embryo sac, embryo in one-cell stage, and endosperm in free nuclear condition (× 207)

Fig. 2 Slightly older stage, showing an increase in the size of the embryo sac and the number of endosperm nuclei, and the spherical embryo with its long suspensor (× 75)

Fig 3 Young embryo and suspensor showing detail of cell structure (× 207)

Fig 4 One cell from nucellus of ovule shown in Figure 2 Large compound starch grains fill the cell (× 430)

Fig. 5 Single compound starch grain (× 1720)

Fig. 6 Outer integument in chalazal region at the stage shown in Figure 2 (× 207).

### PLATE XX

Fig 7 Stage of seed development in which the cotyledons are very evident. Endosperm still in the free nuclear condition (× 40).

Fig 8. Mature seed, showing the endosperm surrounding the embryo (× 40).

Fig. 9. Longitudinal section of mature seed cut at right angles to the flat surface, showing shape of hypocotyl and cotyledons (× 40).

Fig 10. Surface view of outer integument cell in mature seed (× 207).

Fig. 11. Cross-section of cell shown in Figure 10 (× 207).

# PLATE XIX

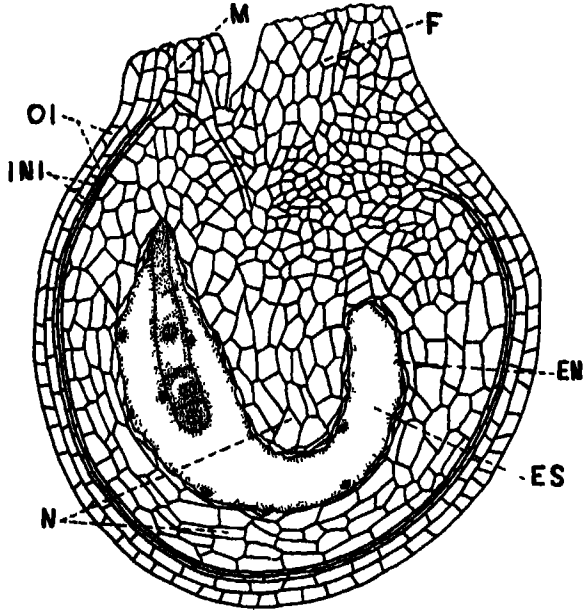

Fig 1

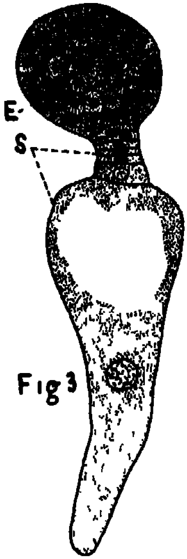

Fig 3

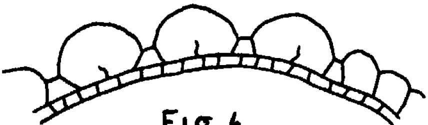

Fig 6

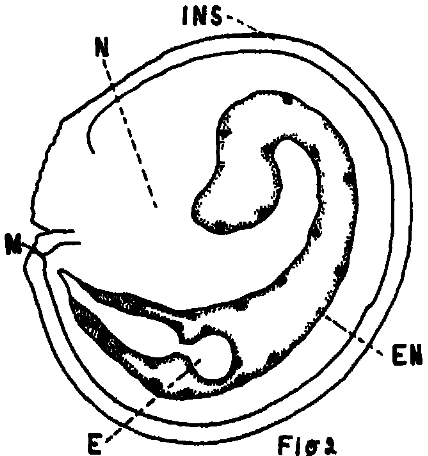

Fig 2

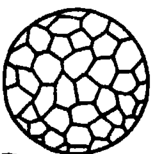

Fig 5

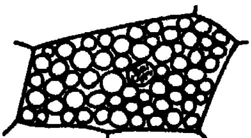

Fig 4

# PLATE XX

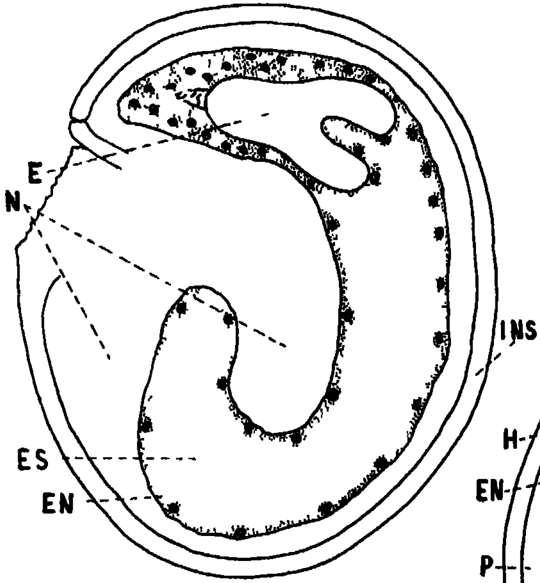

Fig 7

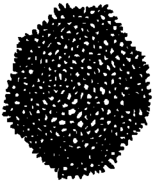

Fig. 10

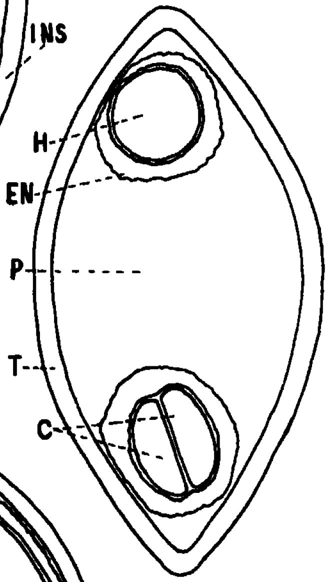

Fig 9

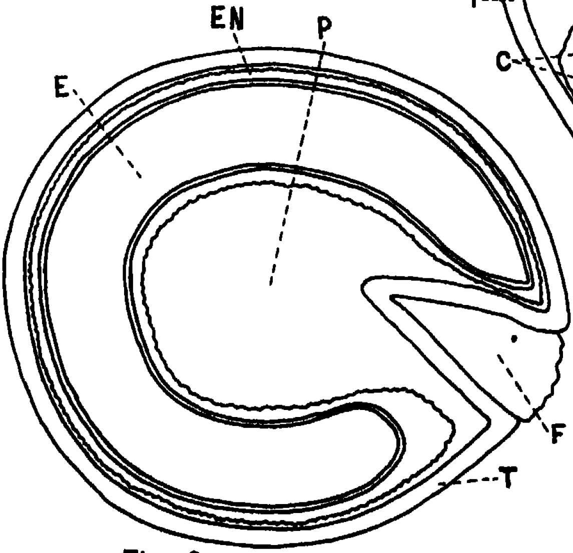

Fig. 8

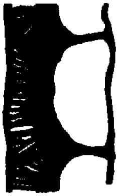

Fig 11

# AN ECOLOGICAL STUDY OF SMITH'S BOG, CHEBOYGAN COUNTY, MICHIGAN

EDITH WOOLLETT, DORIS DEAN AND HELEN COBURN*

SMITH'S BOG (see Map I and Plate XXI) is a small peat bog on the line between Burt and Munro townships, Cheboygan County, Michigan It is an excellent example of a *Carex lasiocarpa* stage in bog development, the *Carex lasiocarpa* mat covering an area of over 23,000 square meters. Near the center is a very small, shallow, open pond approximately 30 meters wide and twice as long. The greatest depth to the false bottom is less than a meter The pond and the surrounding mat are decidedly acid.[1] The pond narrows to a channel which continues to the far southern end of the bog where it disappears into a small lowland forest There is no perceptible inlet or outlet to the bog, so that any drainage is probably due to seepage. The open water of the pond is being invaded by the Castalia-Nymphaea association, followed by the Eleocharis association.

Temperature readings were taken at different depths, the results of which are expressed in the following table

TEMPERATURE OF THE MAT AT VARIOUS DEPTHS

| Site (see map) | A | B |
|---|---|---|
| Air at surface | 19 75° C | 19 75° C |
| Soil at 0 cm. | 19 70 | |

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* Contribution from the Biological Station of the University of Michigan. Doris Dean was primarily responsible for the map, Helen Coburn for the peat readings, and Edith Woollett for the general ecological description, although the three authors are jointly responsible for the whole paper

The work at Smith's Bog was done under the direction and supervision of Professor F. C. Gates at Douglas Lake, Michigan, during the summer of 1924.

[1] Readings taken on the mat and in the water by Dr. Minna Jewell and Harold Brown in the summer of 1924 show pH 4.2 to 4 3

| Site | A | B |
|---|---|---|
| Soil at 10 cm | | 17 55 |
| Soil at 20 cm | 15 10 | 16 85 |
| Soil at 40 cm | 12 65 | 14 05 |
| Soil at 60 cm | 12 00 | 12 50 |
| Soil at 80 cm | 12 00 | 10 70 |
| Soil at 100 cm | | 9 60 |

These results indicate little or no interchange of water in the mat.

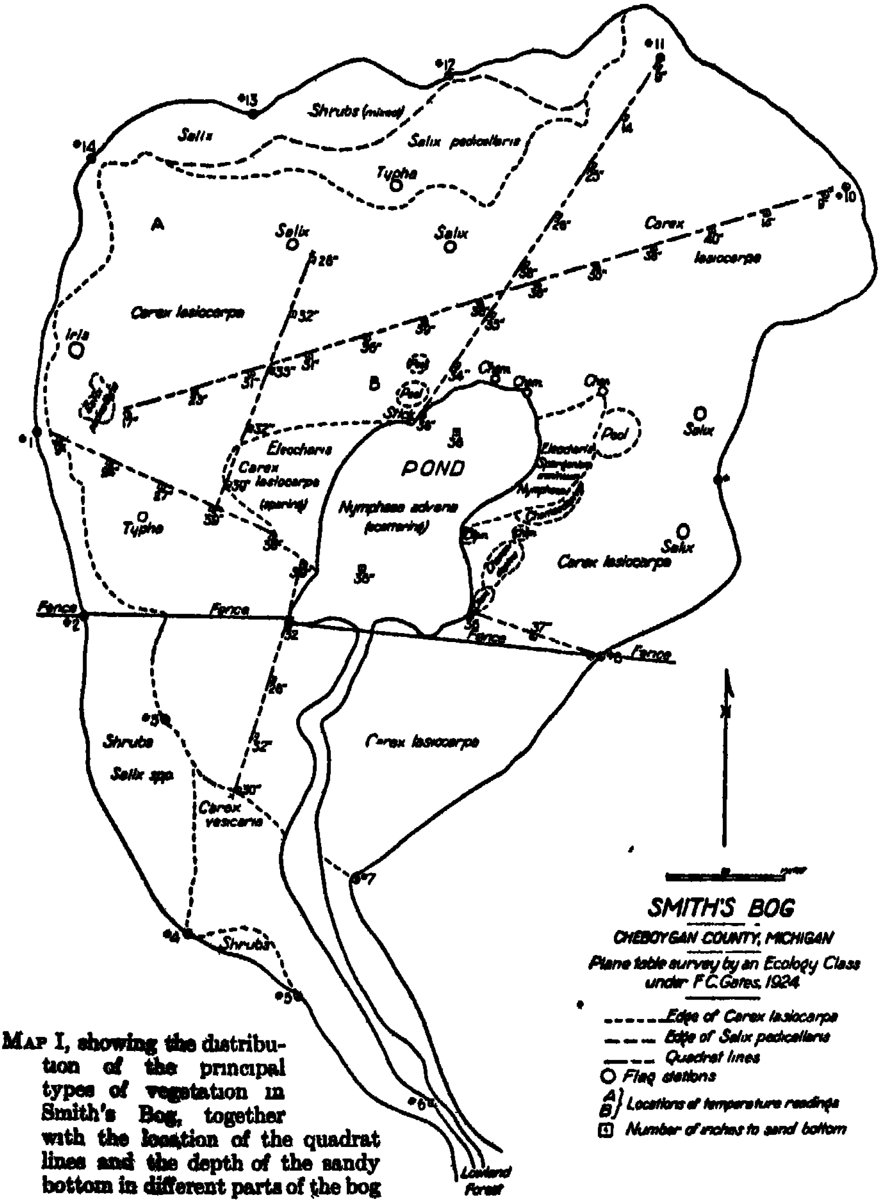
Surrounding the pond is the *Carex lasiocarpa* mat which in most places is fairly dry Where there is considerable water, the mat is still of a quaking character It is essentially level with practically no hummocks or depressions

In 1911 the pond in the center of the bog was four times its present size, but during succeeding years, after the burning of the surrounding woods, it has decreased in size because of the rapid growth of *Carex lasiocarpa.*

In 1916 part of the mat became grounded. During the high water after 1917 some of the mat was rapidly invaded by the high-bog shrub association represented especially by *Salix Pedicellaris.* Chamaedaphne and Nemopanthus had been present at the edge, but fire in 1916 practically eliminated them. The few patches that were left are spreading and new ones are appearing and developing rapidly The Salix consocies together with the Chamaedaphne association is very well represented at the northern end of the bog

Originally the upland area surrounding the present bog was heavily wooded with a mixed pine and hardwood growth. At the southern end, where the present lowland bog forest is found, there was a depression. Here the mixed pine-hardwood growth contained Thuja. Fire and lumbering changed the character of the upland area, since until 1914 a dense mixed aspen growth with trees 6 to 8 meters in height, and from 35 to 40 years old, was replacing the original forest, except at the southern end. Here the pine and Thuja were being replaced by a lowland forest type.

In 1914 fire occurred in this aspen growth, and in 1916 a severe fire burned into the bog. The fire of 1916 burned into the forest at the southern end of the bog without entirely destroying it. At



Map I, showing the distribution of the principal types of vegetation in Smith's Bog, together with the location of the quadrat lines and the depth of the sandy bottom in different parts of the bog

(PAGE 203)

present, surrounded by mixed aspens, are found *Fraxinus nigra*, *Alnus incana* and other lowland species No traces of Thuja are now to be found in the bog

The vegetation of Smith's Bog may be divided according to habitat into the following natural divisions

- A OPEN WATER
  - 1 Castalia-Nymphaea association
  - 2 Eleocharis association (around margin)
- B MAT
  - 1 *Carex lasiocarpa* association
  - 2 Iris association
  - 3 Chamaedaphne association
- C HIGH SHRUBS
  - 1 Nemopanthus consocies of the high-bog shrub association
  - 2 Alnus consocies
  - 3 *Salix pedicellaris* consocies
- D LOWLAND FOREST
  - 1 Fraxinus consocies of the Lowland Forest association

The pond in the center of the bog contains very little open water in comparison to the size of the mat The shore-line is very broken The false bottom is almost 40 cm. below the surface of the pond

The number of plant species found in the water is very small. The floating aquatics are represented by the Castalia-Nymphaea association *Nymphaea advena* is the representative of the association and is found growing in the open water as well as in its typical habitat fairly close to the edge Formerly the Nymphaea grew attached to the *Carex lasiocarpa* mat with its leaves floating in the water beyond the edge of the mat As the mat became grounded and the water-level lower, Nymphaea established itself in the open water and at present seems to be increasing in abundance.

On the mat where there are still small sections of open water is the Eleocharis association, dominated by *Eleocharis acuminata* and *Eleocharis palustris* There is very little *Scirpus atrocinctus* found along the eastern side of the lake, and, on the whole, the Eleocharis association is being invaded by the Carex mat. Eleocharis itself is, however, still well represented on the mat, especially on the south side of the fence, crossing the bog in line with Stations 2 and 8 (see Map). It is found growing in jagged patches around the pond At the edge of the water on the east side of the pond there is practically a pure stand of Eleocharis covering a small area Here it is gradually invading the open water as the pond becomes drier, and in turn is being invaded by the Carex.

The *Carex lasiocarpa* association is the extensive association of the bog. In some places *Carex lasiocarpa* forms pure stands covering many square meters, and in other places *Dulichinum arundinaceum* is the only other representative of the association found with the Carex

One thousand and fifty contiguous quadrats, one square meter in size, located definitely (see Map), were taken on the *Carex lasiocarpa* mat [2] The species in these quadrats numbered twenty-one, of which the following were most richly represented (the numbers following being the frequency indices) *Carex lasiocarpa*, 100, *Dulichium arundinaceum*, 37 1, *Eleocharis palustris*, 36 2; *Eleocharis acuminata*, 19 7, *Juncus canadensis*, 12 9, and *Carex crinita*, 8 9 The total flora on the mat, regardless of quadrat lines, numbered twenty-nine The average number of species per meter quadrat for the whole mat was 2 65, which shows a very small percentage of plant species

Peat readings taken on the mat at intervals of about 15 2' meters (50 feet) on the established quadrat lines indicate the depth to sand over much of the bog as between 50 and 100 cm

The peat obtained in 1924 consisted largely of decaying vegetable matter from the mat and was soft in character There was no blue clay or marl present. This is different from the results obtained at Mud Lake Bog,[3] Cheboygan County, Michigan, where the peat-borer indicated blue clay in abundance.

The thin triangular leaves of *Carex lasiocarpa* extend from the mat, which rises and falls with the water There is an average of

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[2] These data are used by the authors in a paper entitled "Application of Gleason's formula to a *Carex lasiocarpa* Association, an Association of Few Species," *Bull. Torr Bot Club*, 52 (1925) 23–25

[3] Louise Goe, Elsie Erickson and Edith Woollett, "An Ecological Study of Mud Lake Bog, Cheboygan County, Michigan" *Papers of the Michigan Academy of Science, Arts and Letters*, 4 (Part I) 297–310

488 culms to the square meter Gradually the accumulation of leaves and the branched root system form mats which are hard to break, providing an excellent place for other plants to grow After a *Carex lasiocarpa* mat has become fairly solid, other sedges and grasses and a few other plants become established. *Carex crinita*, *Carex stricta* and *Carex sterilis* are found on the mat with *Carex lasiocarpa* and, especially where the Carex is rather sparse, *Dulichium arundinaceum* is very abundant *Potamogeton heterophyllus*, found in such places, is a relict of the Potamogeton association

There are a very few logs near the edge of the *Carex lasiocarpa* mat They help to establish plant life upon it In several places *Chamaedaphne calyculata* has become well established by growing out along logs This is especially true of clumps on the east side of the bog The fire in 1916 destroyed the Chamaedaphne completely around much of the edge It is because of this that it is not more plentiful On the northeastern side of the bog, however, it is now rapidly gaining ground

The *Carex lasiocarpa* mat as a whole is gradually becoming drier and drier, for in all but a few places it has become well grounded Particularly between Stations 1 and 14, and 1 and 2, plants characteristic of the Iris association are found *Iris versicolor*, *Dryopteris thelypteris*, *Potentilla palustris* and *Lysimachia terrestris* are abundant *Iris versicolor* is found in clumps, especially between Stations 1 and 14 at the edge of the bog. *Potentilla palustris* is found more or less scattered throughout the mat Dryopteris is found at the very edge of the mat and is not very abundant

*Typha latifolia* as an invader is present at the southern end of the bog where it is invading the Carex It has established itself fairly well.

At the northern and northeastern sides of the bog the Iris association is missing and Chamaedaphne, *Salix pedicellaris* and Nemopanthus are found Behind them is a rather thick growth of aspens

The whole bog is open and the plants are exposed to wind, light and heat. The only shade is that afforded occasionally by the few clumps of Salix or Chamaedaphne The water-supply, although abundant, is acid and therefore the whole vegetation is of a xeromorphic character

The *Salix pedicellaris* consocies is dominant, especially at the northeastern and southern ends of the bog where it grades into the lowland bog forest *Salix pedicellaris* is the dominant species It grows in with the Chamaedaphne and is gradually establishing itself well onto the mat

In the small area of lowland forest at the southern end of the bog *Fraxinus nigra* is a conspicuous tree Many of the trees have swollen bases, which may be due to the stagnant conditions, although a cross-section shows no difference in structure between the swollen trunk and any other part of the tree[4] The trunks average 22 1 cm in diameter and the swollen portions about 37 1 cm

*Alnus incana* and *Acer rubrum* are also abundant Seedlings of *Ulmus americana* make up the bulk of the sparse ground cover The forest is extending out into the bog by its invasion of the high-bog shrub association

### SUMMARY

1 Smith's Bog in Cheboygan County, Michigan, is an excellent example of a *Carex lasiocarpa* stage in bog development, the Carex covering an area of over 23,000 square meters

2. Since the very low water of 1921 a small pond in the center is gradually diminishing in size The false bottom is about 40 cm below the surface of the water, sand occurs at a depth of one meter

3 Peat readings taken indicate no blue clay or marl present

4 The pond is being invaded by the Eleocharis and Carex associations

5 The Carex mat has been well grounded and succession is now very rapid.

6 Patches of Chamaedaphne on the Carex mat are spreading and new ones are appearing in various places in the Carex

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[4] F C Gates and C O Erlanson, "Enlarged Bases in *Fraxinus nigra* in Michigan," *Botanical Gazette*, 80 107–110

7 Especially at the northern and eastern sides of the bog *Salix pedicellaris* is most abundant

8 At the southern end of the bog is a lowland forest with *Fraxinus nigra, Alnus incana* and *Acer rubrum* in abundance At the present time no traces of Thuja are to be found

9 The bog as a whole is rapidly becoming drier and it is predicted that in ten to twenty years the water will entirely disappear, leaving a dry Carex meadow

10 This meadow will be invaded by the Chamaedaphne, Myrica, Salix, and high-bog thicket associations and eventually the lowland forest at the southern end may extend well into the open bog

## LIST OF HIGHER PLANTS FOUND IN SMITH'S BOG

An asterisk (*) denotes that the species is present on the *Carex lasiocarpa* mat

Acer rubrum
Acer saccharum
Achillea millefolium
Agropyron repens
Agrostis palustris
Alnus incana
Alopecurus aristulatus
Amelanchier canadensis
Anaphalis margaritacea
* Andromeda polifolia
Antennaria canadensis
Apocynum androsaemifolium
Asclepias syriaca
Aster spp
Betula glandulosa (previous to 1914)
Betula papyrifera
Bidens vulgata
* Calamagrostis canadensis
Carex brunnescens
Carex cephalantha
* Carex crinita
Carex disperma
Carex gracillima
Carex hystricina
Carex intumescens
* Carex lasiocarpa
* Carex sterilis
* Carex stricta
Carex vesicaria
Castalia odorata
* Chamaedaphne calyculata
Cirsium lanceolatum
Coptis trifolia
Cornus canadensis
Cornus stolonifera
Diervilla diervilla
Dryopteris spinulosa
Dryopteris thelypteris
* Dulichium arundinaceum
* Eleocharis acuminata
* Eleocharis palustris
Epilobium angustifolium
Erigeron philadelphicus
Erigeron ramosus
* Eriophorum callithrix
* Eriophorum viridicarinatum
Eupatorium purpureum
Fagus grandifolia
Fragaria virginiana
Fraxinus nigra
Galium boreale (previous to 1914)
Galium trifidum
Gaultheria procumbens
Hieracium aurantiacum

Homalocenchrus oryzoides
* Hypericum virginicum
Ilex verticillata
* Iris versicolor
* Juncus brachycarpus
* Juncus canadensis
Lactuca canadensis
Lonicera canadensis
Lonicera oblongifolia
Lycopus communis
* Lysimachia terrestris
* Lysimachia thyrsiflora
Mentha canadensis
* Menyanthes trifolia
Nemopanthus mucronata
* Nymphaea advena
*Panicularia borealis
Panicularia nervata
Poa compressa
Poa palustris
Poa pratensis
* Polygonum amphibium
Populus grandidentata
Populus tremuloides
* Potamogeton heterophyllus
* Potentilla palustris
Prunus nana
Prunus pennsylvanica
Pteris aquilina
Pyrola secunda obtusata
Pyrus americana
Quercus borealis
Ranunculus pennsylvanicus
Rhamnus alnifolia
Rhus glabra
Rhus glabra borealis
Rubus strigosus
Salix discolor × rostrata
Salix lucida
* Salix pedicellaris
* Salix sericea
Scheuchzeria palustris
* Scirpus atrocinctus
Solidago sp
* Sparganium minimum
Sphagnum sp
Spiraea alba
Taraxacum vulgare
Tilia americana
Trientalis americana
* Typha latifolia
Ulmus americana
Unifolium canadense
Vaccinium angustifolium
Vaccinium canadense
Vaccinium nigrum
* Viburnum cassinoides
Viola pallens

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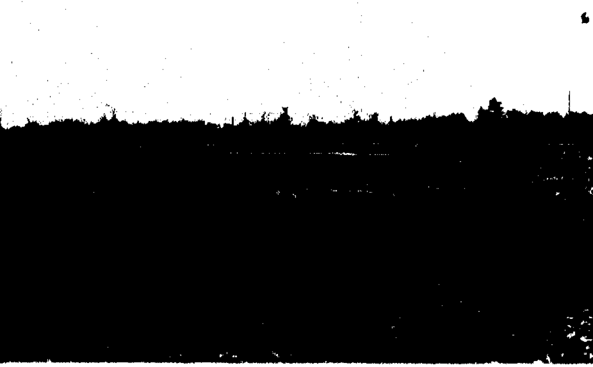
## EXPLANATION OF PLATE XXI

FIG 1 A general view of Smith's Bog from the northwest, showing *Salix pedicellaris,* part of the area of Chamaedaphne, a broad expanse of *Carex lasiocarpa,* the pond in the center, and the vegetation on the upland southeast of the bog Photograph by F C Gates, August 1, 1915

FIG 2 A detailed view towards the southern end of Smith's Bog, showing *Carex lasiocarpa,* which bushes of *Salix pedicellaris* are invading Photograph by Helen Coburn, August, 1924

FIG 3 A view in the lower part of Smith's Bog, showing an expanded part of the little stream that drains the pond The edge of the small lowland forest is visible at the left, and a shrubby area is in the central background Photograph by Helen Coburn, August, 1924.



# THE SECOND INDUSTRIAL CONFERENCE AND ADJUSTMENT OF DISPUTES

SAMUEL M LEVIN

BETWEEN October 6, 1919, and March 6, 1920, two conferences took place at Washington, each at the behest of the President The purpose in both cases was to bring together a group of men familiar with our industrial problems, to devise plans for the attainment of more harmonious relations between employers and employees The first conference consisted of a rather numerous body (fifty-eight in all) classified for convenience into three groups, representing employers, employees and the public

It is sufficient to say, with respect to this conference, that after some twelve days of wrangling in committee meetings and interminable discussion in regular session, the organization broke up, when on October 22 Mr. Gompers and the labor representatives withdrew. The next day the President, speaking through Mr Franklin K Lane, chairman of the conference, requested that, because of change of conditions, the work should now be carried on by the public group The public group, before disbanding, submitted a brief report, which contained the following words "We believe that the right of workers to organize for the purpose of collective bargaining with their employers, through representatives of their own choosing, cannot be denied or assailed. As representatives of the public, we can interpret this right only in the sense that wage earners can be free to choose what organization or association they will join for this purpose."[1] This declaration was nothing more than a compound of the essential elements of the two contending resolutions proposed in the First Conference,[2] in other words a recognition of the right to bargain collectively, and at the same time the recognition of "shop industrial councils or other lawful forms of association" Finally the public group offered the suggestion that the President select a small committee to take up the matter of preparing a general program.

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[1] *Annals of American Academy of Political and Social Science*, July, 1920, p 131

As a result Mr. Wilson appointed a new committee of seventeen, exclusive of William B Wilson, chosen chairman, and Herbert Hoover, vice-chairman. It is a matter of interest to note the personnel of this new body. There were "three ex-governors of states, two former attorneys-general of the United States, a former Secretary of Commerce and Labor, three college professors, two news proprietors, an efficiency engineer, a railroad official, the head of a large mail order house in Chicago, the counsel of a large industrial corporation, and a retired lawyer and economist"[3] One misses labor altogether, and yet here was a group selected to deal with matters of primary interest to millions of wage earners On the other hand there is an impressive inclusion of lawyers and of men with experience in executive and administrative functions of government — a rather homogeneous body that could well be expected not to go too far afield from the safe and sane

The Conference met at Washington on December 1 On December 19 it presented a preliminary statement to the public, giving an outline of the recommendations it was working on, and inviting criticisms and suggestions It reconvened on January 12, when it had on its hands a considerable body of criticism and comment to consider, and in the succeeding deliberations called a number of representatives of labor and capital to present the situation from their respective sides. The meetings continued to March 6, 1920, when the final report was submitted to the President

A study of the contents of this document makes it clear that it is the plan for the adjustment of disputes (Part III) that gives us the essential result of the weeks of planning and deliberation. Parts I and II (some eight pages), however, are of importance in affording us a view of the theoretical perspective in which this work was consummated Part IV, dealing with a miscellany of items in the industrial field, further reveals something of the attitude and underlying philosophy of the group with respect to such subjects as collective bargaining, hours of labor, housing, wages, profit sharing, unemployment and employees of government Part V is the conclusion These words are worth noting "The machinery of coöperation and adjustment which we recommend we believe to have permanent value as an agency of industrial progress "[4]

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[2] *Proceedings of the First Industrial Conference*, pp 141 and 175

[3] *Annals of the American Academy of Political and Social Science*, July, 1920, p 132

The structure of this machinery is decidedly intricate. The plan contemplates Regional Boards, Boards of Inquiry, a National Industrial Board, umpires and panels With regard to labor, it is clear that the Conference was anxious to embrace in the scope of its plan labor organized in trade unions and labor organized within the plant In fact nothing stands out more conspicuously in the Report of the Conference than emphasis on employee representation, as a basis for cooperation between employee and employer. We read "The guiding thought of the Conference has been that the right relationship between employer and employee can best be promoted by the deliberate organization of that relationship That organization should begin within the plant itself Its object should be to organize unity of interest and thus to diminish the area of conflict "[5] Yet the fact stands out that so far as the actual plan for the adjustment of disputes is concerned, there is no specific mention of employee representation in any one of the fifteen pages given to it in the report

The clause referring to submission of disputes speaks of "the appointment of representatives by *both sides*,"[6] as constituting an agreement for submission to the Regional Adjustment Conference The term 'both sides' is inclusive, calculated to fall in with the needs of any body of laborers whatsoever On the other hand the Report declares that "the panels of employers shall be classified by industries, the panels of employees shall be classified by industries and subclassified by crafts" [7] This intimates the inevitable necessity, in any machinery for adjustment, to make use on either side, of industries and crafts Again the rule is set down that an agreement "shall have the full force and effect of a trade agreement, which parties to the dispute are bound to carry out" [8] A trade agreement must refer to one made between an employer and his own employee representatives or one between an employer and a labor organization

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[4] *Report of the Industrial Conference*, p 51

[5] P 6 Throughout the rest of the paper page references without further data are to the *Report of the Industrial Conference.*

[6] P 17

There are eight varieties of Regional Boards or Conferences specified or hinted at in the report

1 Simple regional Adjustment Conference, for settlement of disputes, relating to wages, hours, and working conditions Consists of chairman, appointed by the President, four members selected from panels, two from each side, and four from parties to the dispute, two representing employers and two the employees Unanimity required to give agreement between parties the force of a collective bargain [9]

2 Additional Regional Conferences under vice-chairmen appointed by National Industrial Board to insure prompt action or where there is multiplicity of disputes [10]

3 Compound Conferences, specially created to deal with disputes extending beyond the boundaries of a single region Chairman designated by National Industrial Board Members chosen from combined panels and regions involved in dispute [11]

4 Regional Adjustment Conference created by transformation of Regional Board of Inquiry, if at any time during progress of inquiry both sides shall have selected representatives and agreed to submit the dispute for adjustment [12]

5 Interpretative Boards, made up of representatives of parties to dispute on Regional Adjustment Conference, before which dispute was heard In case of disagreement, chairman decides [13]

6 Fact-finding Regional Conference If no agreement is reached by Conference, and additional information is required to make report to the National Industrial Board or to umpire, the Conference for that time and for that purpose has power of Board of Inquiry [14]

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[7] P 17 [8] P 21 [9] P 13 [10] P 16
[11] P 20 [12] P 19 [13] P. 21 [14] Pp 18–19

7 Public Utility Regional Adjustment Conference Consists of the chairman, one employer and one employee from panels, four representatives from party to dispute (two from each side), and two representatives of governmental authority "which has power to regulate the service of the public utility "[15]

8 Public Service Regional Adjustment Conference Consists of two representatives from legislative branch of government authorized by law to make appropriations, two representatives from branch of government in position of employer, two from employees in public service in which the question arises, and two members to be selected by the representatives of the employees from the first twelve names on the general panel[16]

There are several varieties of Boards of Inquiry

1 Simple Board of Inquiry Consists of two employers from top of employers' panel for industry concerned, two employees from the top of employees' panel, and chairman of the Regional Adjustment Conference The Board takes cognizance of a dispute if both parties, or either, refuse to submit it to a Regional Adjustment Conference Chairman has right to vote[17]

2 Enlarged Board of Inquiry (if either side selects representatives, thereby agreeing to submit dispute to adjustment) Such representatives may select two names from their panel and may sit on the Board of Inquiry[18]

3 Board of Inquiry transformed into a Regional Adjustment Conference[19]

4 Board of Inquiry for a dispute extending beyond the boundaries of a single region[20]

5 Public Utilities Board of Inquiry constituted of same membership as Regional Adjustment Conference in field of public utilities[21]

6 Additional Regional Boards of Inquiry under vice-chairmen[22]

There is a National Industrial Board consisting of nine members, appointed by the President, divided into three groups representative of employers, employees, and the public For less important cases, it may subdivide into three parts, each part including one member from each group[23] The functions of the Board exhibit considerable range of variation The following may be specified

1 General supervisory power and power to make rules governing administration of plan[24]

2 May require regional chairman to take cognizance of a dispute, or may suspend the operation of the regular machinery[24]

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[15] P 24 [16] P 27 [17] P 19 [18] P 14 [19] P 19
[20] P 20 [21] P 24 [22] P 16. [23] P 23 [24] P 15

3. Board of Appeal on questions of wages, hours and working conditions which cannot be adjusted by a Regional Adjustment Conference. In such cases a unanimous vote is necessary.[25]
4. Board of Appeal on all other questions which may come before Regional Adjustment Conference, and voluntarily submitted to it by parties to the dispute. Vote is unanimous or otherwise in accordance with terms of submission.[26]
5. Board of Appeal for trade agreements, in case an industrial agreement made between employer and employee is filed with the National Industrial Board, and when dispute fails to be adjusted by machinery provided in agreement.[27]
6. Board of Appeal for disputes involving public utilities. Majority vote necessary, provided at least one public representative concurs. Binding upon employer unless disaffirmed within ten days after award, and upon employees unless disaffirmed within twenty days.[28]

There is no appeal in disputes involving public employees. Upon failure of Regional Adjustment Conference to reach unanimous agreement, the parties to the dispute may select an umpire, who may decide on all questions, even open and closed shop.[29] The umpire does not function in behalf of public employees.[30]

The system of panel representation is as follows:

1. Panel representatives to constitute simple Regional Adjustment Conference. The chairman takes twelve names from the top of the panel for the industry concerned and twelve from the panel for the craft or crafts concerned. The representatives of the two sides then choose two each from the names on their respective lists.[31]
2. Public Utility Representatives, one employer representative and one employee representative chosen by parties to the dispute from first six names on their respective panels.[32]
3. *a.* Public Service Representatives, Secretary of Commerce and Secretary of Labor act together in providing regional panels "of persons who are broadly familiar with the different classes of services performed by public employees in the region." Two representatives of the employees are selected from the first twelve names on the general panel.[33]

   *b.* Regional panels named above may be named by governor of any state "for use in connection with any question affecting the public employees of that state."

The Secretary of Commerce and Secretary of Labor are involved to the extent that the former prepares the employers' panel, and the latter that of the employees, "after conference with the employers and employees respectively, of the region" The two secretaries are to revise panels annually in conference with the employers and employees of each region The President appoints members of the National Industrial Board as well as the regional chairmen

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[25] P. 15. [26] Pp 15–16. [27] P. 22. [28] P 25. [29] P 20.
[30] P. 28. [31] P. 18. [32] P. 24. [33] P 27.

An analysis of the plan for the adjustment of disputes makes clear the fact that there is nothing about it that savors of compulsory submission of disputes or compulsory arbitration. Rather the emphasis is laid on the desirability of agreement between the parties The regional chairman, as a matter of fact, does not take cognizance of a dispute until he has had satisfactory evidence that an honest attempt has been made to settle by agreement of the parties or by existing machinery And even after the dispute is taken in hand by the Regional Conference, the aim is adjustment and not arbitration Such emphasis is further shown by the possibility of agreement of parties on submission even during the progress of an inquiry It may likewise be noted that in view of the fact that the chairman possesses no vote in such conference, it is deemed that the two sides are evenly balanced, and are thus favorably constituted to make possible an amicable settlement.

There is, however, an indirect pressure for submission, and this arises as a result of the machinery for inquiry, which begins to function the moment it becomes clear that either party or both refuse to submit the dispute to the Regional Conference This in fact means, within limits, compulsory investigation in all cases coming within the scope of the plan Its importance depends, first, on the power to subpoena and examine witnesses under oath, the Board of Inquiry being the only body vested with this authority, except the one instance where the Regional Adjustment Conference is granted similar authority,[34] secondly, on the fact that the right of inquiry is placed in the hands of a body in which the employers and employees are indirectly represented, and, thirdly, that the report is made public

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[34] "If no agreement is reached by the Conference, and in the opinion of the chairman additional information is required to make a report to the National Industrial Board or to an umpire, the Regional Adjustment Conference shall at that time and for that purpose have all the powers of inquiry and right to subpoena which are vested in the Regional Board of Inquiry" Pp 18-19

The efficacy of this arrangement depends, then, on a willingness to submit to an inquiry under such circumstances, or, on the other hand, to submit to a Regional Adjustment Conference But the fact needs to be noted that submission to such a Conference means much more than this one step implies It means, to use the language of the Report, "in case of failure of the Conference to agree unanimously, to accept the award of the National Industrial Board, or of an umpire, on any question relating to hours, wages, and working conditions," and also "an agreement that they will continue or reestablish and continue, until the case is concluded, the status that existed at the time the dispute arose "[85] It is a choice, then, between inquiry on one side, and relinquishment of the strike on the other, unless in the event of submission the party in question is disposed to break its pledge, and ignore the consequences of placing the facts before the public In the last resort that is all the plan contemplates in the way of penalty (either in case of failure to submit or non-compliance after submission), but it makes a difference as to whether a public statement is of the nature merely of the findings of a fact-finding body, or whether it amounts to a condemnation of a party bearing the guilt of a broken agreement

There certainly is no reason why shop organizations should not be willing to submit their disputes in the manner proposed But the case is not so clear when it comes to regular unionists Organized labor will find it hard to forget that it has failed to win any special recognition in collective bargaining, and that all the way along it is merely put on a level with the new employee representation. Again, the National Industrial Board is essentially an arbitrating body, the members of which are appointed by the President But organized labor by bitter experience has learned to distrust arbitrating bodies so constituted, bodies not committed to anything as far as the requirements of the plan are concerned, not possessing the right of inquiry or to subpoena and examine witnesses, not bound by any mandate to maintain a scientific staff, to investigate and ascertain the facts of any situation The Railway Labor Board, of course, is a notable instance of labor's disillusionment And yet the National Industrial Board is the overshadowing power in the whole undertaking Once a case is submitted to a Regional Conference, there is no more retreat, that in itself is an agreement to accept the services of the National Board or of an umpire There is, in other words, after this first step is taken, *a compulsory acknowledgment* of the final authority of the National Industrial Board or of an umpire, unless one is willing to face the penalty prescribed

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[85] Pp 17-18.

There is another question falling in this category, and that has to do with the panels The panels are prepared by the Secretary of Commerce for the employers and by the Secretary of Labor for the employees, after conference in each case with representative groups of employers and employees Not to consider the possibility of politics entering into appointments the complexion of these panels must, of necessity, depend on the wisdom, the economic understanding, the fairness, and the good will of the two secretaries But the term 'employer' or 'employee,' the moment it is applied to the domain of opinion, thought and policy, with the intention of suggesting the connotation of a definite, prescribed pattern of thinking with regard to these things, becomes at once a snare and delusion That it has little or no validity can scarcely be doubted Not all employers are obsessed with the same notions concerning industrial issues, nor do they begin to correspond in intelligence, economic philosophy, experience and temperament, and what is said of employers may likewise be averred with respect to employees No set of documents is so illuminating in this regard as the *Proceedings of the First Industrial Conference,* which reports verbatim the ideas, opinions and beliefs of more than a score of representative figures in the American business world, arbitrarily classified into two groups, the employing group and the public.

It was Mr Gompers who later pointed out that "in the group of representatives of the public there was a larger number of employers than was contained in the group representing employers, and that these employers in the public group were the employers of more workers than were the employers of the employers' group "[36] Yet it was the latter body of employers that refused with inexorable determination to make any compromise with the representatives of labor and the public on the issues presented in the original resolution with respect to collective bargaining It was the employers in the public group who, in general, gave expression to the liberal point of view, who evinced a willingness to meet labor in a coöperative spirit, and who showed little patience with the sterile argumentation and the casuistries indulged in by the others

There is no assurance in this plan that a man sitting in the Cabinet and calling himself Secretary of Labor is going to pick the right sort of employees' panel. What if he gives preference to company union men? There is nothing at all to stop him from doing this, and presumably it would not be a difficult matter to argue in favor of that sort of proceeding. As it is, the regional conference is a patchwork affair, for the panel representatives do not do much more than add bulk to the body made up of the original disputants But, if matched against the laborers there is going to be an employers' panel, the laborers cannot overemphasize the necessity of assuring themselves the right sort of *employees'* panel Does the proposed plan offer this assurance? This is an important question to answer.

It is quite possible, as has been pointed out, that the plan may serve to weaken collective bargaining between employers and regular trade unions. All that is necessary is for the employer to refrain from entering into an agreement so as to force the dispute into the hands of a Regional Adjustment Conference or else force an inquiry. To trade unionists such a possibility is of sufficient weight to cause serious concern, for there can be no question as to which of the two methods they would prefer — that of the trade agreement by collective bargaining, or that by way of the Regional Conferences It is in view of this sort of situation, largely, that the attitude of the authors of the Conference Report on employee representation looms up as significant

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[36] *American Federationist*, 26 1125.

As to the scope of the plan, though the Report speaks of disputes in general, there are certain limitations The following may be given as a summary

1 A Regional Adjustment Conference must take cognizance, in accordance with provisions, of disputes relating to hours, wages, and working conditions[37]

2 The National Industrial Board may act as a board of appeal on all other questions coming before a Regional Adjustment Conference, voluntarily submitted to National Industrial Board by parties There is no appeal in matters involving policy such as open or closed shop[38]

3 An umpire may decide on all questions (including open or closed shop), except those involving public employees, and his decision is to have the effect of a unanimous decision of a Regional Adjustment Conference[39]

4 Public utilities, other than those covered by the Transportation Act, are included in the scope of the plan

5 Public Employees Agreement by Regional Conference takes form of recommendation to appropriate legislative body There is no appeal to National Industrial Board, no inquiry, no reference to an umpire

6 Consideration by the National Industrial Board of any industrial agreement made between employers and employees, and filed with the National Industrial Board by consent of parties

7 The authority of the National Industrial Board "to issue instructions to the general chairmen, concerning the character of the disputes of which they should take cognizance"[40] This would indicate that the scope of the plan, so far as Regional Adjustment Conferences are concerned, is ultimately in the hands of the National Industrial Board

Taken by and large, one is inclined to reach the conclusion that, in devising the plan for adjustment of disputes, the Conference has done a fairly good piece of work The principles underlying it are sound, viz agreement between parties if at all possible, agreement or adjustment along lines of conciliation and arbitration; national and local machinery carefully interlinked, provision for appeal; no compulsion. In the words of one writer, "The immense advantage of such a system over lack of any system must be patent" It could be depended on at least "to throw light where light is more needed" But the comment goes on further to point out that there is no provision by which the regional boards "can be guided by a unified body of national doctrine, that they are inert until there is trouble, and that the National Industrial Tribunal should have power to recommend legislation to Congress and greater powers of investigation into all phases of industrial unrest"[41] These criticisms are in point. They must be remembered in connection with the other items discussed, such as the status and attitude of organized labor, the structure and functions of the National Industrial Board, the panel system, the prominence given to employee representation and the effect on collective bargaining Yet after all one must remember that it is impossible to devise a plan that is altogether faultless The plan for the adjustment of disputes, taken by itself, if adopted with a few necessary modifications, would give us a foundation for new and better work as time goes on

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[37] P. 13. [38] Pp. 15–16 [39] P 20. [40] P 23

Now, as regards the case of public utilities and public employees, reference has already been made to modifications which the Conference deemed necessary, to accommodate details and procedure to the new situation Thus, in the Public Utility Regional Conference Board there are two representatives of the government authority which has power to regulate the service of the public utility, and the Public Service Board is organized in a manner still different So far as a Public Utility Board of Inquiry is concerned, it is constituted of the same membership as the Regional Conference for such cases, whereas there is no Board of Inquiry at all in public service disputes From the standpoint of effectiveness of decisions and right of appeal, the National Industrial Board, in case a public utility appeal is involved, is authorized to reach its decision by a majority vote, provided at least one public representative concurs, but the decision is binding upon the employer only if within ten days after the award is rendered it is not disaffirmed, and upon employees if not disaffirmed within twenty days. If not so disaffirmed, or when unanimous decision is rendered by Regional Board, or when decision is made by an umpire, the agreement or award assumes the binding character of a trade agreement, as in other cases There is nothing in all these provisions to suggest any limitation in the field of public utilities, having to do with the nature of the dispute or class of employee, though it would appear that inasmuch as a Board of Inquiry must include two members representing the government, the government simply by refusing to appoint such members could make inquiry impossible and thus summarily dispose of all this machinery for the dispute in question

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[41] *New Republic*, 21 · 157

In disputes involving government employees, the government body may or may not avail itself of the machinery A Regional Adjustment Conference is convened by the Chairman, on *request* of the administrative head of the government department "standing in relation of employer, or on request of such a substantial number of employees as to satisfy the chairman that the question is of sufficient importance to justify the convening of a Regional Adjustment Conference " The Regional Conference, at best, is empowered merely to make recommendations to the appropriate legislative body that has power to fix wages, hours and working conditions.[42] Only such classes of public employees are to be subject to the plan as the government authority designates. There is no Board of Inquiry, no appeal, no reference to an umpire

The significance of these provisions becomes more patent, when the fact is noted that there is no interdiction against the strike in disputes affecting public utilities,[43] whereas there is such interdiction in disputes affecting public employees We read that "Government employees individually are free to leave the service, *but no group* should be permitted to strike or to threaten concerted cessation of work." [44] On another page, however, we find that "the right of the individual to retire is limited by his duty to give due notice, dependent upon the character of his service " [45] So far as affiliation with organizations that resort to the strike is concerned, the plan forbids such affiliation "to policemen and others, whose duties relate to the administration

[42] P. 43 [43] P. 26 [44] P 43 [45] P 41

of justice and the preservation of life and property" By inference one is justified in concluding that teachers, mail-carriers, clerks, may so affiliate, despite the fact that the strike is outlawed But a positive affirmation to this effect is not made Moreover, the question arises as to the benefit of joining a striking organization if the people who join are forbidden to strike One does not expatriate himself into a prohibition country in quest of beer, wine, or other strong drink

It remains to point out that Mr Gregory differed from the other members of the Conference in the matter of the right to strike in the case of essential industries, such as "railroads other than transportation systems, or water, light, gas, telegraph and telephone plants and groups of coal mines," on the ground that the continuous operation of these is "essential to the convenience and frequently the very existence of the general public" His idea was to make strikes and lockouts in these industries unlawful, "during the time the proposed tribunals were seeking to determine and publish the facts and settle the issues involved, and during the subsequent brief period within which the parties to the controversy were to accept or reject the award made, and during the period covered by the award in case both parties accepted it" In other words, this does not contemplate compulsory settlement or even compulsory submission of disputes, it does mean compulsory cessation of striking activities, in such cases, after submission. Since, however, the parties to the controversy are privileged to reject the award made, the compulsion, it is clear, becomes nil once the parties decide on rejection If they do accept the award it becomes operative during the life of the agreement, a situation tantamount on one side *to legal enforcement of a trade agreement*, and on the other to compulsory relinquishment for the time being of the right to strike Mr. Stuart, another member of the Conference, shared the views of Mr Gregory except as to their applicability to coal mines, which he did not regard as public utilities

Undoubtedly there are good grounds for discriminating between ordinary disputes and those affecting public utilities and government In general, there is no basis for taking umbrage at the provisions bearing on *public utilities* Organization of any kind is permitted, the right to strike is permitted, the entire machinery of adjustment, subject to slight modifications, continues to function in a manner to take cognizance of such disputes and to help in their disposal But the case is altogether different with employees of the public There the right to strike is denied, the right of affiliation with striking organizations so strongly limited as to make such affiliation meaningless, the machinery for adjustment stops with the Regional Adjustment Conference (there is not even a Board of Inquiry) whose findings are mere recommendations If public employees are asked to give up the right of using the strike, even the right of organization, in self-defense or to improve their status, they must have positive, unquestioned assurance that their case will be taken in hand by properly constituted tribunals There has to be machinery for handling such cases impartially and scientifically, as, for example, in Australia, where Parliament in 1911 intrusted to the Australian Court of Arbitration the function of settling "wages, hours, and conditions of labor for federal public servants."[46] The Conference itself recognizes that "the government must be a just employer"[47] But that any body of intelligent business men, government executives and economists can hold that this need is fulfilled by the slight contrivance of an emasculated Regional Conference is hardly credible

The result, of course, must be for the making of an even more pronounced antagonism on the part of labor The policy of organized labor with respect to this matter has of late been made clear One of the provisions in the program of reconstruction of the American Federation of Labor (1919) endorsed by the Executive Council is as follows "Public employees must not be denied the right of organization, free activities, and collective bargaining, and must not be limited in the exercise of their rights as citizens."[48] The Convention of the American Federation of Labor in Atlantic City in the spring of 1919 opened the door to the affiliation and organization of the Boston police.

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[46] H B Higgins, *Harvard Law Review*, 29 38 [47] P. 42.

[48] Daniel Bloomfield, *Modern Industrial Movements*, p 356.

Labor held its ground on this question in the meetings of the First Industrial Conference, where, it will be recalled, the employers' resolution distinguished between private employment and government employment in the matter of collective bargaining and the right of unions to be represented by men of their own choosing, the resolution making the concession only to the former Matthew Woll argued that, inasmuch as the railroad brotherhoods were then government employees, the declaration would at least by inference deny organization and representation to railroad workers[49] Even John Spargo, a member of the public group declared "I affirm there is no body of employees anywhere in the world who more need the right to bargain collectively than those who are employed by a great modern government with its bureaucratic methods "[50] All this is sufficient to enforce the thought that labor is not unaware of the gravity of this question and that it cannot be disposed of by a device like the one suggested by the Conference

It is impossible to escape the conclusion that following upon the heels of the ill-fated First Conference the Second failed to improve its opportunity. The shadow of the First seemed to have descended on its successor Except for the plan proposed for the adjustment of disputes, which is not without merit, but which is to some extent marred by the fears and prepossessions of the personnel, the Report has in it little or nothing that deserves to be remembered It may be, as one critic has suggested, that the Conference kept at a safe distance from a good many troublesome issues because unanimity was the desideratum, but if that was the case the members have no one but themselves to blame for their failure to make a contribution of recognized worth to society

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[49] *Proceedings of First Industrial Conference*, p 189

[50] *Ibid*, p 208

# THE RELATION OF THE SOIL SURVEY TO LAND CLASSIFICATION

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WE are nearing the end of our easily available virgin timber resources Presently we shall be dependent on our annual forest production for our timber supplies Our agricultural expansion has absorbed all of the natural high-quality farm and grazing lands and has extended to lands of lower or marginal quality Meanwhile our population continues to grow in numbers yearly This increase in population is paralleled by a growing demand for the products of the land — food, fiber, and forest products — and the use of land for other purposes than production Out of this growing demand competitive uses for land arise, and when, as frequently happens, those competitive uses meet and compete for lands which are of marginal quality for either use, then there is confusion in determining which use shall prevail In the past such determinations have mainly been made by the slow and costly process of 'trial and error'

Because of the loss in time and money and human energy which such 'trial-and-error' experiments have involved, as well as the abuse which they have inflicted on our land resources, we hear a more and more frequent call for 'land classification' No one seems to know definitely just exactly how this land classification should be applied in detail There seems to be only one point of agreement, namely that we should have such a classification.

Granted! A land classification But for what purpose and on what basis? For the purpose of establishing land use on the basis of utility. But use, at least for the bulk of our land area, implies production, and many factors other than land enter into the economics of production. Labor, capital, markets, transportation, supply and demand for the product, and a host of other changeable economic factors will give an ever changing complexion to any land classification based on utility

When we admit that we cannot classify land in a fixed, arbitrary, 'once-and-for-all-time' sort of manner, then the problem becomes much simpler We shall inventory the relatively stable and tangible physical characteristics of land like soil character, topography, climatic influence, ability to produce certain kinds of plants and animals, and we shall appraise the influence of the relatively unstable and intangible economic characteristics.

With such inventories and appraisals before us, we can set a classification for today, knowing and anticipating that ten years from today or fifty years from today we can readily re-classify, if necessary, to accord with an altered economic status. It is even probable that, with a full and detailed inventory of the more stable physical characteristics, we can so completely anticipate the trend and effect of the less stable economic factors as to allow a relatively permanent classification to be made today

Here, then, the relation of the soil survey to land classification becomes easily apparent The soil survey is an inventory of the soil character of the land, an inventory of one of the principal physical characteristics of land. It identifies and defines the limit and extent of land areas of like and unlike soil character, and under the recently adopted methods of soil classification a close correlation is being established between soil character as measured by the Soil Survey and the natural ability of certain soils to produce certain types of plants and animals as measured by actual practice In a classification of land which contemplates the selection of land for crops, pasture and forest on the basis of physical suitability for such use, the soil survey becomes, therefore, not only a valuable aid, but a vital and necessary part of the inventory on which to rest the classification.

The 1923 *Year Book of the United States Department of Agriculture* presents a clean-cut picture of our crop land, pasture land, and forest land requirements for sustaining the population which we shall have acquired by the middle of the present century. The specialists of this Department estimate that our population will have reached a total of 150,000,000 in about the year 1950, and that to sustain this number of people there will be required 38,000,000 acres more crop land and 2,000,000 acres more humus pasture land than we now possess Their study concludes that, after allowing for an area of forest land equal to the present forest area (483,000,000 acres), nearly 400,000,000 acres of potential crop land remain from which to select the required 40,000,000 acres of crop and pasture land Practically all of the 400,000,000 acres are, however, either inferior in quality or require drainage or irrigation It is obvious that to obtain the 40,000,000 acres of highest available utility for crops and pasture from this great area careful selection is involved

A careful, deliberate selection of 40,000,000 acres of new crop and pasture land at the rate of 1,000,000 acres annually out of a total available crop land area of 400,000,000 acres cannot be intelligently accomplished without a full and detailed inventory of the physical characteristics of the available lands and a careful appraisal of the effect of its economic environment on its utility.

The Land Economic Survey is making two types of records on lands of known character and economic environment with the hope that, when such records have been obtained for a sufficient number of areas, they will be of assistance in selecting certain lands for forest, crop and pasture use. One type of records registers the relation of soil character to the type and status of present agricultural utilization The other registers the relation on soil character to the character of the original forest growth

Those of you who have traveled through the rural districts have no doubt observed that on certain soils farming is apparently a prosperous business, while on other soils it consistently fails to prosper unless sustained by some set of abnormally favorable circumstances.

With this in mind the Land Economic Survey devoted a few days last season to crop-mapping for the purpose of recording an apparent correlation between soil type and established agricultural utilization.

On each of four important soil types one section of land was selected. These sections were selected by consulting the Soil map in order to get an area of 640 acres in which the type of soil to be represented was strongly dominant in extent, and by consulting the Cover map for a section in which the farm development was as typical as possible for the community The soil, crop and land utilization maps, together with their summary tables, are given below for each of the four soil types

## ONAWAY LOAM

The Onaway Loam is a gently rolling loam soil with a reddish-brown, moderately friable, gravelly, gritty, clay subsoil. In the virgin soil the surface layers are seldom more than slightly acid, and the subsoil at two feet is high in lime The original forest growth was a heavy stand of mixed hardwoods hard maple, beech, elm and basswood On this soil a diversified type of production prevails. The crop land is used for oats, wheat, barley, peas, corn, potatoes, timothy and clover hay, and rotated pasture

In the adjoining sections on the same soil type alfalfa was also used as a hay crop to some extent This section had about ten acres of idle or unused land on a black swamp soil, Lupton Peat (Soil type No 30), and a poorly drained swamp border soil, Bergland Clay Loam (Soil type No 82). The land and buildings on this section had an assessed value of $25,200 in 1924. One hundred and twenty-three animal units were maintained on the ten farms. Fifty-five of these were milk cows and thirty-six were classed as other cattle The farms on this section had every appearance usually taken to indicate a prosperous type of agriculture.

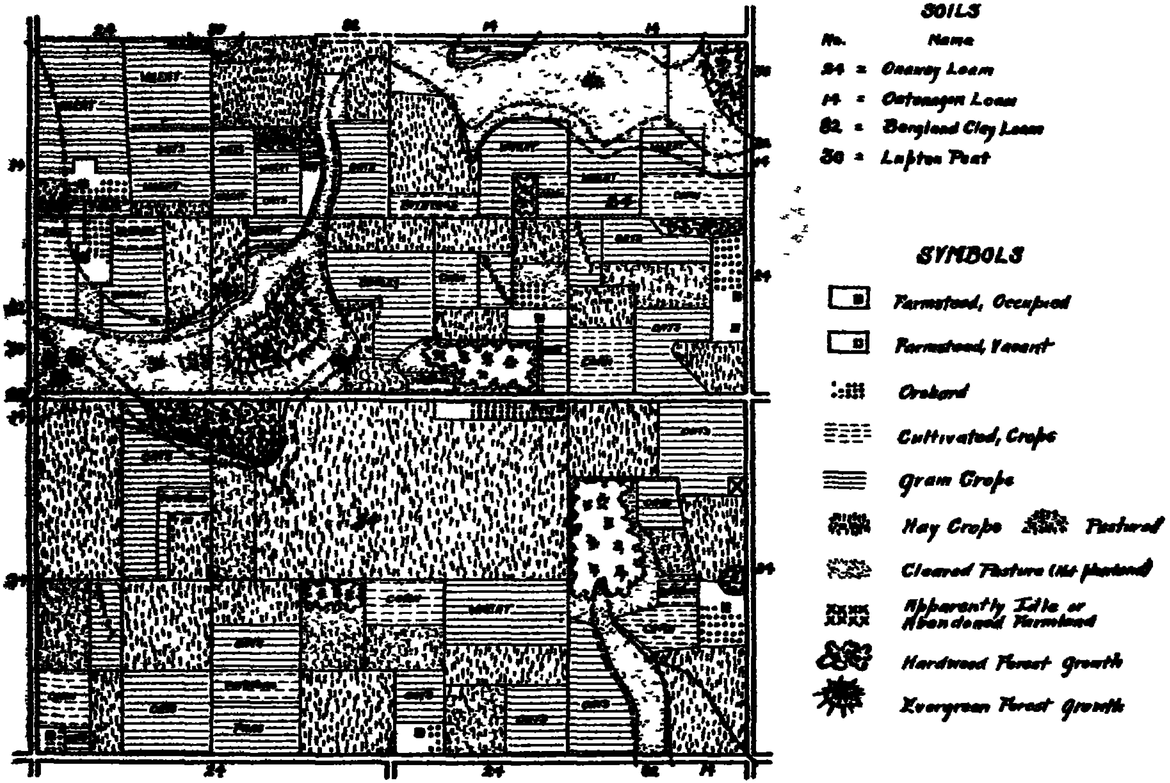

FIG 9 ONAWAY LOAM

TABLE I

SHOWING ONAWAY LOAM DOMINANT

| SOIL TYPES | Onaway Loam | Ontonagon Loam | Bergland Clay Loam | Lupton Peat | Total acres on all soils | Percentage of all soils |
|---|---|---|---|---|---|---|
| | Acres | Acres | Acres | Acres | | |
| Total area | 496 | 36.5 | 46.5 | 37 | 616 | |
| Farmstead and gardens | 15 | | | | 15 | 2.3 |
| Orchards | 12 | | | | 12 | 1.9 |
| Cultivated crops | 49 | 4 | | | 53 | 8.3 |
| Grain Crops | 152.5 | 14.5 | 1 | | 168 | 26.2 |
| Hay crops | 235.5 | 9 | 8.5 | 1 | 253 | 39.5 |
| Cleared pasture | 12 | 10 | 36 | 17 | 75 | 11.7 |
| Apparently idle or abandoned farm land | | | 1 | 3 | 4 | 0.6 |
| All cleared land | 476 | 36.5 | 46.5 | 21 | 580 | 90.5 |
| Public highways | | | | | 24 | 3.8 |
| Forest growth | 20 | | | 16 | 36 | 5.7 |

*Total assessed value of land and buildings, $25,200*

*Animal units maintained*

| | |
|---|---|
| Milk cows | 55 |
| Other cattle | 36 |
| Sheep, hogs, horses | 32 |
| Total | 123 |

## ONTONAGON LOAM

The Ontonagon Loam is a smooth-lying to nearly level loam soil with a heavy, gritty, red-clay subsoil The surface layers of the virgin soil are acid, but the clay subsoil is high in lime at and below two and one-half feet. The original forest growth was mixed hardwood and white pine. On this soil there is less diversification in crop production. The crop land is used for oats, barley, wheat, timothy and clover hay, and rotated pasture. Six

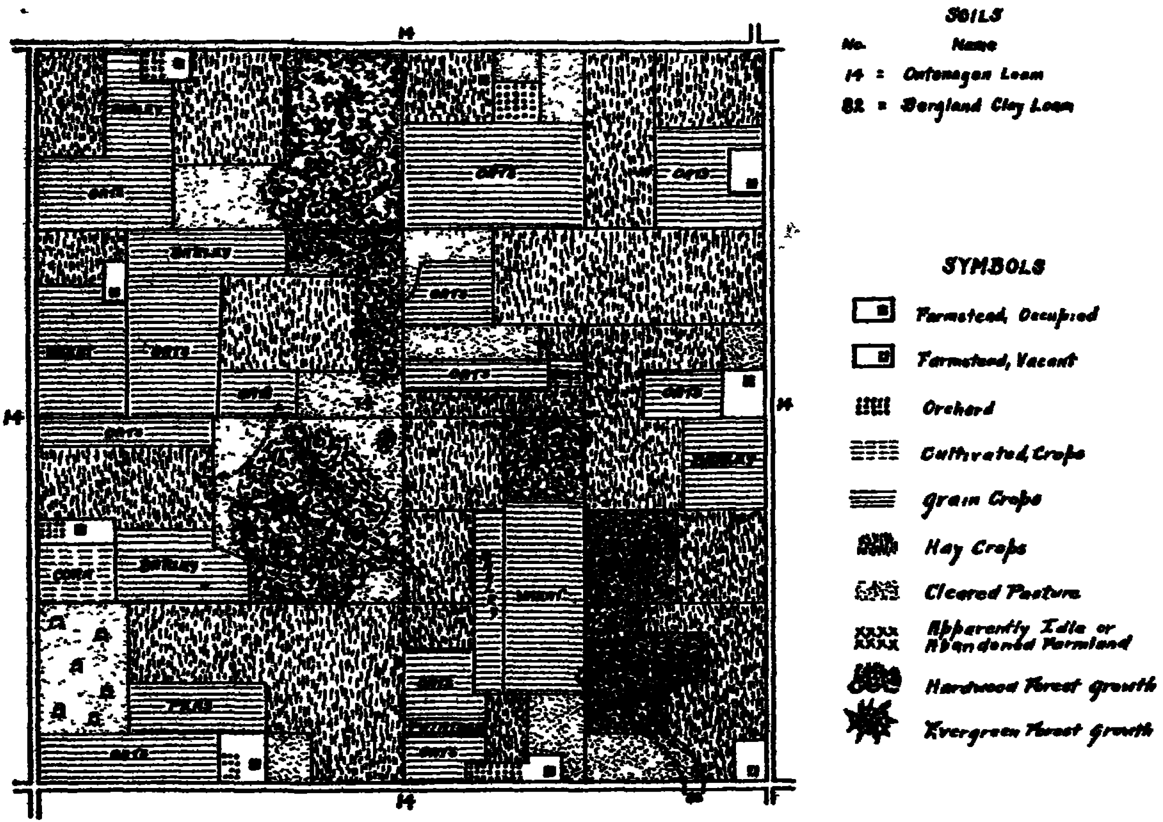

FIG. 10 ONTONAGON LOAM

acres of corn and potatoes constituted the entire area of cultivated crops in this section in 1924. There is no idle or unused land, but about seventy-four acres are in grazed wood lot. These uncleared woodland pastures are largely on the Bergland Clay Loam (Soil type No. 82), a black low-lying swamp border soil with a grayish heavy clay subsoil. The land and buildings had an assessed value of $22,100 in 1924 and ninty-seven animal units were maintained on the eight farms. Fifty of these animal units were milk cows and twenty-four were classed as other cattle.

## TABLE II

### SHOWING ONTONAGON LOAM DOMINANT

| SOIL TYPES | Ontonagon Loam | Bergland Clay Loam | Total acres on all soils | Percentage of all soils |
|---|---|---|---|---|
| | Acres | Acres | | |
| Total area | 601 | 23 | 624 | |
| Farmstead and gardens | 11 | | 11 | 1.7 |
| Orchards | 8 | | 8 | 1.2 |
| Cultivated crops | 6 | | 6 | 0.9 |
| Grain crops | 190 | | 190 | 29.8 |
| Hay crops | 248 | | 248 | 38.8 |
| Cleared pasture | 83 | 4 | 87 | 13.6 |
| Apparently idle or abandoned farm land | | | | |
| Public highways | | | 16 | 2.5 |
| All cleared land | | | 566 | 86.0 |
| Forest growth | 55 | 19 | 74 | 11.5 |

*Assessed value of land and buildings*, $22,100

*Animal units maintained*

| | |
|---|---|
| Milk cows | 50 |
| Other cattle | 24 |
| Sheep, hogs, horses | 23 |
| Total . . . . . . . . . | 97 |

## SUMMERVILLE STONY CLAY LOAM

The Summerville Stony Clay Loam is a smooth-lying, shallow, stony, clay loam soil The underlying bed rock of limestone outcrops on the surface or underlies at depths that seldom exceed one and one-half or two feet The original forest growth was a mixed stand of hardwoods and conifers, maple, birch, elm, cedar, balsam and spruce. About one quarter of this section consisted of swamp soil, Rifle Peat (Soil type No 20), and a black low-lying swamp border soil, Bergland Stony Clay Loam (Soil type No 82 X), both of which are mainly occupied by a cedar-tamarack forest growth This, however, is a typical association About fifty-five acres in fields of irregular outline are devoted to crop production The crop consists of corn, corn and sunflowers mixed, feed roots, timothy and clover, and alfalfa for hay The entire area of the Summerville Stony Clay Loam not in crops, farmstead and home orchard is used as permanent pasture, except about an acre and a half on which one farmer piled the stone taken from his plow land The land and buildings in this section are assessed at $6,400 in 1924 or an average of $10 per acre. Eighty-one animal units are maintained on the three farms, of which sixty-nine are milk cows and six are classed as other cattle

This is low grade crop land, but fairly productive grazing land These farm owners had suited their use of the land to its ability to produce They buy all their feed grain and concentrates, pasture the bulk of the land, raise only roughage, maintain practically no animals except milk cows, bulls and work stock, and depend solely on their dairy products for an income

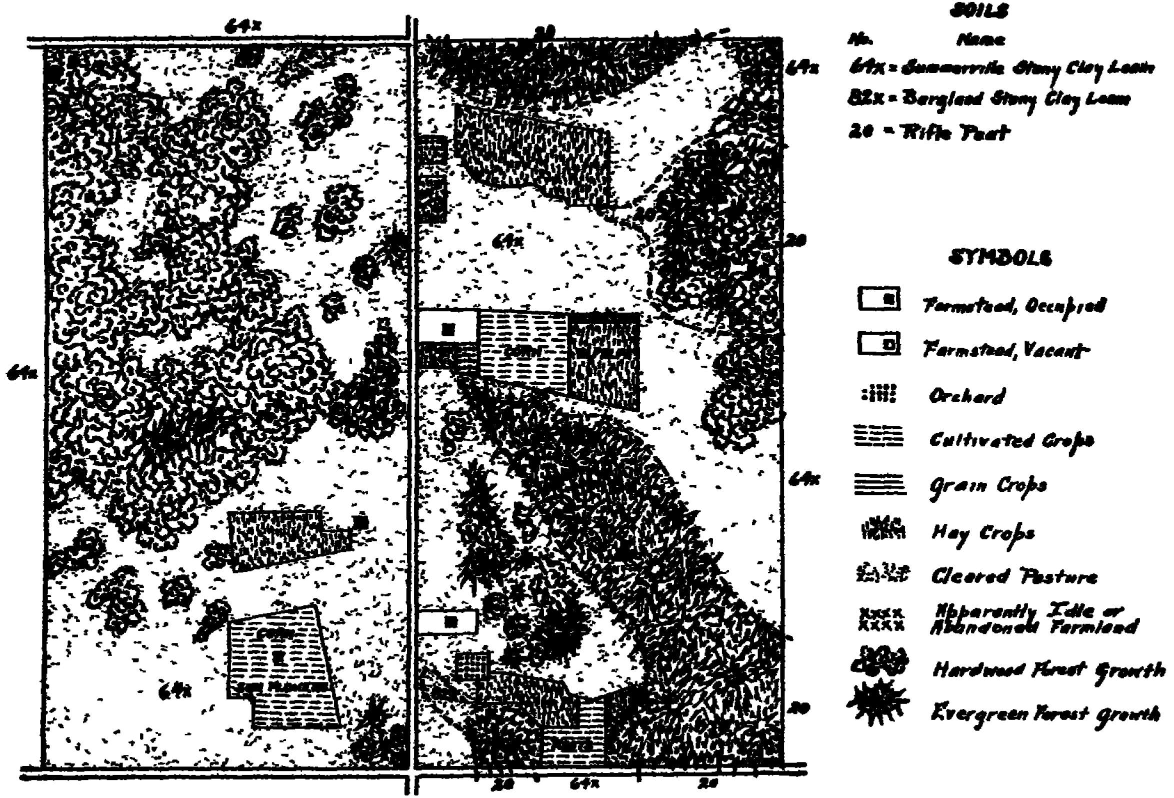

FIG 11 SUMMERVILLE STONY CLAY LOAM

## TABLE III

### Showing Summerville Stony Clay Loam Dominant

| Soil Types | Summerville Stony Clay Loam | Bergland Stony Clay Loam | Rifle Peat | Total acres on all soils | Percentage of all soils |
|---|---|---|---|---|---|
| | Acres | Acres | Acres | | |
| Total area | 442 | 114 | 70 | 626 | |
| Farmstead and gardens | 4 | | | 4 | 0.6 |
| Orchards | 3 | | | 3 | 0.5 |
| Cultivated crops | 25 | | | 25 | 3.9 |
| Grain crops | | | | | |
| Hay crops | 33 | | | 33 | 5.2 |
| Cleared pasture | 287 | 3 | | 290 | 45.4 |
| Apparently idle or abandoned farm land | 1 | | | 1 | 0.1 |
| All cleared land | 351 | 3 | | 354 | 55.3 |
| Public highways | | | | 12 | 2.2 |
| Forest growth | 91 | 111 | 70 | 272 | 42.5 |

*Assessed value of land and buildings*, $6,400

*Animal units maintained*

| | |
|---|---|
| Milk cows | 69 |
| Other cattle | 3 |
| Sheep, hogs, horses | 9 |
| Total | 81 |

## GRAYLING SAND

The Grayling Sand is a level, light brown sand on rather coarse yellow sand It is a typical, dry, droughty, 'jack pine plain' soil, highly acid in all its layers. A few acres in the southwest corner consist of a stream-bottom soil which is subject to stream overflow, Griffin Sandy Loam (Soil type No. 75)

One hundred and sixty-seven acres on five forties of this section have been cleared for crop land. All but about twenty-five acres of this cleared land lies idle and unused. The twenty-five

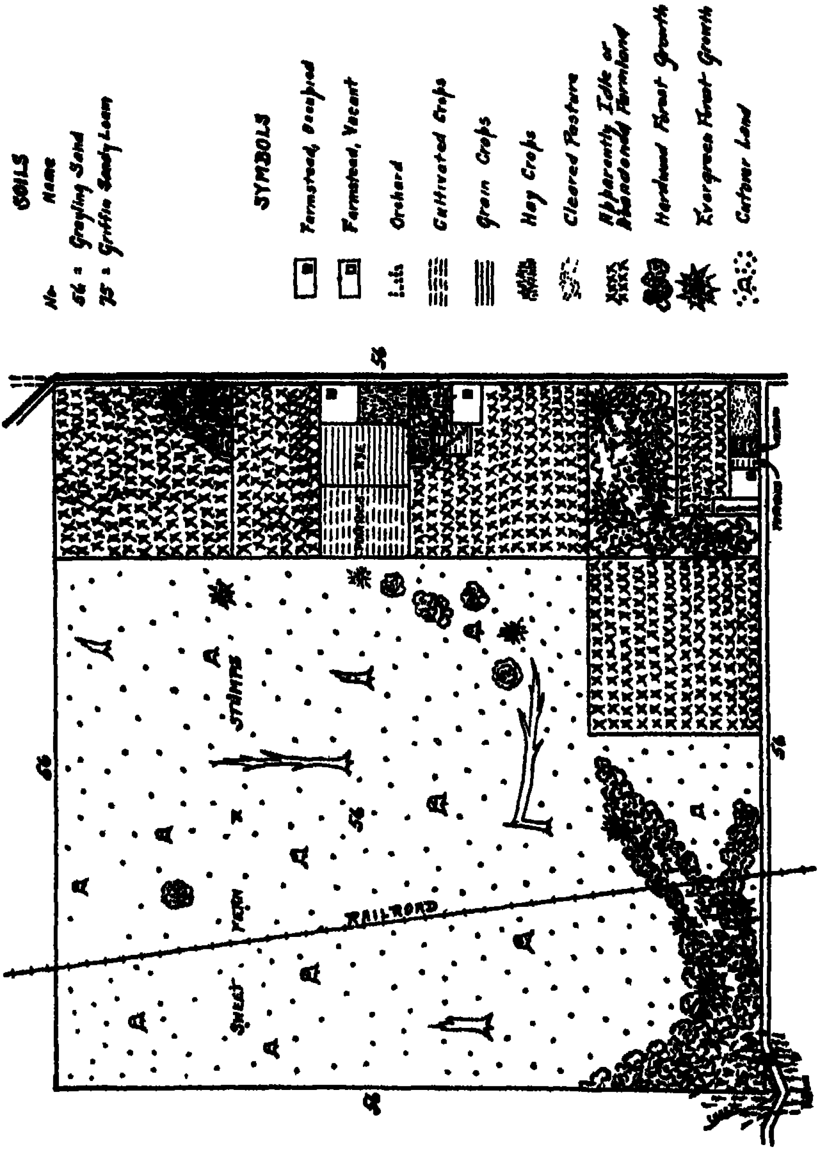

FIG 12 GRAYLING SAND

acres are returning a very meager yield of potatoes, rye and hay. The carrying capacity of pasture land on this soil is low Two of the families in the three occupied farmhouses apparently do not receive their maintenance from the land The assessed value of the land and buildings in 1924 was about $4,500. Fewer than five animal units are maintained by the three families living on the land And this condition prevails in spite of the fact that this section fronts on an improved trunk line highway and is but one mile from the county seat

## TABLE IV

### SHOWING GRAYLING SAND DOMINANT

| SOIL TYPES | Grayling Sand | Griffin Sandy Loam | Total acres on all soils | Percentage of all soils |
|---|---|---|---|---|
| | Acres | Acres | | |
| Total area | 630 | 2 | 632 | |
| Farmstead and gardens | 5 | | 5 | 0 8 |
| Orchards | | | | |
| Cultivated crops | 7 | | 7 | 1 1 |
| Grain crops | 8 | | 8 | 1 2 |
| Hay crops | 2½ | | 2½ | 0 4 |
| Cleared pasture | 2½ | | 2½ | 0 4 |
| Apparently idle or abandoned farm land | 142 | | 142 | 22 2 |
| All cleared land | 167 | | 167 | 26 1 |
| Public highways | | | 8 | 1 2 |
| Forest growth and cutover land | 463 | 2 | 465 | 72 7 |

*Approximate assessed value of land and buildings, $4,600*

*Animal units maintained*

| | |
|---|---|
| Milk cows | 2 |
| Other cattle | – |
| Sheep, hogs, horses | 2 |
| Total | 4 |

The Land Economic Survey's 'soil-forest' record grew out of an impression that a relationship existed on certain sandy soils between the type of soil and the density, size and proportion of white Norway pine in the original forest growth

To test this impression a half-acre plot of cutover land was selected on each of five different soil types The number of white and Norway pine stumps on each plat was tallied and the circumference of each stump recorded From this information the basal area (which is the total cross-sectional area of trees) of white and Norway pine was determined for each plat. The results of this basal area tally are presented as a progress report in the following table[1] The results are striking but untrustworthy, by reason of the meager data collected Further tallies will be made on the same soil types in other localities to support or refute these results.

| TYPE OF SOIL | Number of stumps per acre | | Basal area in sq ft per acre | |
|---|---|---|---|---|
| | White pine | Norway pine | White pine | Norway pine |
| Saugatuck sand | 96 | 48 | 176 8 | 51 0 |
| Rubicon sand | 50 | 58 | 96 9 | 71 4 |
| Grayling sand | 22 | 40 | 11 1 | 13 3 |
| Coloma sand * | 63 | 43 | 137 5 | 45 8 |
| Ogemaw loamy sand | 70 | 20 | 245 9 | 32 8 |

* Average of two plots

Have we here an indication that our soil classification or that the soil type parallels the forester's site classification for these two species of pine? If so, what value might a soil classification be to the forester in arriving at a site classification for the denuded forest lands which are not re-stocking?

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[1] From Land Economic Survey records made by L. R. Schoenmann, staff soil surveyor, and H. R. Sayre, assistant forester

Mr. J. O. Veatch[2] has kindly loaned me some of his data on the relation of soil type to the growth of green standing timber, which show that on the Osceola Soil type the slash pine reached a height of less than 30 feet at an age of fifty years, and to judge from the appearance of the rate of growth-curve, it had at that age practically reached its maximum height on this soil On the De Sota Soil type it reached a height of 50 feet in forty years and was just nearing its maximum height development. On the Okechobee Soil type it had reached a height of 50 feet in twenty-five years and was still a considerable number of feet below its probable maximum height development.

These data are presented simply to indicate that, regardless of the present or future demands for land area for one or several types of utilization, the actual experience of established utility, and natural adaptation and productivity correlate rather closely with soil character and condition This correlation constitutes one important basis from which (1) to project any type of proposed use into areas not so utilized, or (2) to weigh the suitability of certain available areas for competing types of use when the soil character, climate and economic environment are known

From the standpoint of area our three major uses of land are for crops, pasture and forest In an assignment of land area to these uses we are bound, except under very unusual circumstances, to follow closely the soil's natural willingness and ability to produce the crops, the grasses and trees which we need By designating soil character the Soil Survey assists in charting the natural willingness and suitability of land for these types of production and to this extent the Soil Survey has a relation to land classification and a function in the careful selection of our annual requirements of 1,000,000 acres of new crop land from the potentially available area of 400,000,000 acres.

MICHIGAN LAND ECONOMIC SURVEY
EAST LANSING, MICHIGAN

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[2] Soils Sections, Michigan State College.

# THE INFLUENCE OF JOINTS IN THE FORMATION OF THE ISLANDS AT THE WESTERN END OF LAKE ERIE

CHARLES W COOK

WHILE carrying on some geological investigations on Pelee Island in Lake Erie, the writer was impressed by the frequency with which lineaments were observed A straight cliff would appear in one direction, along the extension of a joint plane, and in the opposite direction, along the same line, would appear an island, not infrequently seeming to have a correspondingly straight side A further investigation of the problem has resulted in an accumulation of data which seem to leave but small doubt that the formation of the islands at the western end of Lake Erie has been very strongly influenced, if not controlled, by joint planes

The principal joint directions as determined on Pelee Island fall into three sets, approximately, N 45° E and N 45° W, N. 15° E and N 75° W, and N 75° E and N 15° W. An examination of Figure 13, which is based upon data taken from the Coast and Geodetic Survey chart, shows that many of the larger features of the islands and the basin of Lake Erie surrounding them present a striking parallelism with these joint directions This is especially true if the nature of Pelee Island itself is considered. Pelee Island is made up of a number of 'rock islands' joined together by unconsolidated materials The location of these 'rock islands' is shown on Figure 13 by the dotted lines Attention is called to the way in which they line up with one another and with the other islands in the principal joint directions. Also the general trend of many of the contour lines and depressions in the basin floor in relation to the joint directions is to be noted. Unfortunately the data

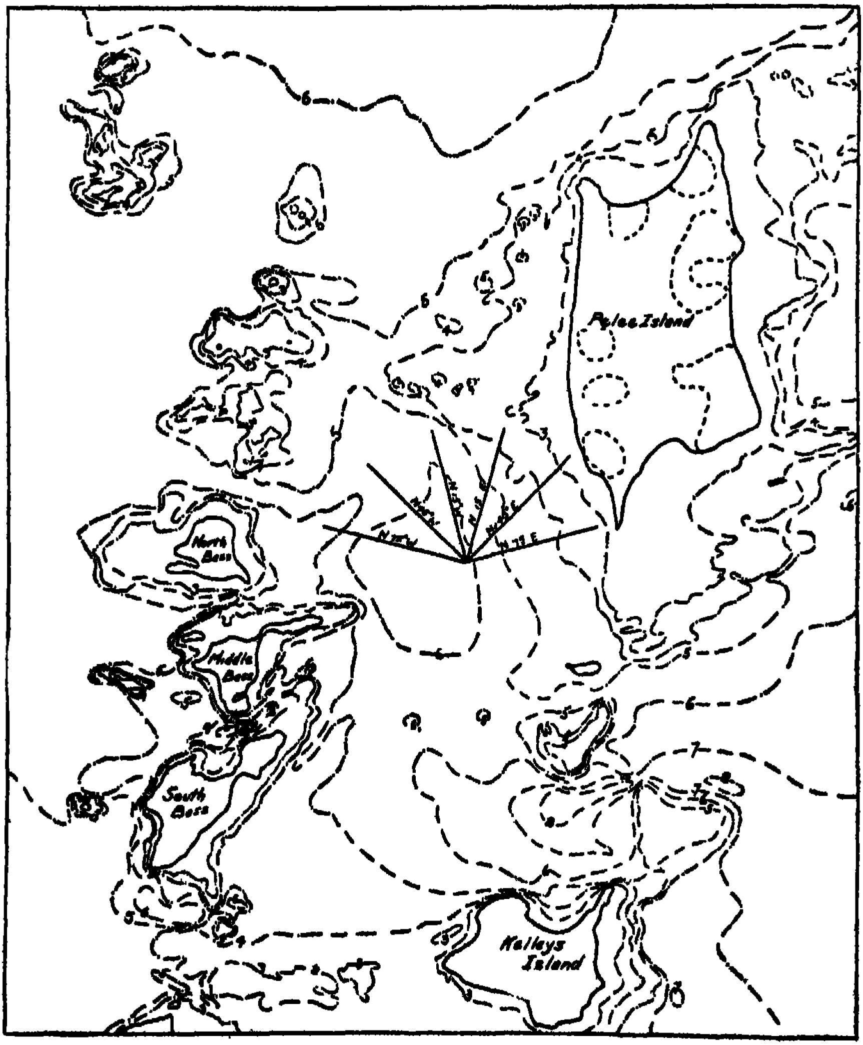

FIG. 13, showing the Parallelism between Topographic Features and Principal Joint Directions from the Lake Survey chart are not sufficiently complete to enable us to distinguish in most instances whether hard rock or loose material is found on the bottom of the lake at various points However, it seems to the writer, that the parallelism of these features with certain definite directions is too striking to be due merely to coincidence and it is his belief that any unconsolidated material on the lake bottom would tend to obscure rather than to emphasize these features

If detailed instead of general relationships are studied, the parallelism is even more striking as may be seen by an examination of Figures 14 and 15 In Figure 14 the twenty-one foot depth-line of Pelee Island has been traced and around it have been drawn straight lines parallel to the principal joint directions The parallelism seems altogether too pronounced not to be due to some definite cause. Further attention is called to the very striking parallelism of the indentations at the southern and southeastern parts of the island. It should perhaps be stated that the twenty-one foot depth-line was chosen rather than the shore-line in order to avoid, so far as possible, modifications of the shore-line due to wave action

Figure 15 is a representation of North Bass, Middle Bass and South Bass islands treated in the same way The parallelism of the twenty-one foot depth-line and the principal joint directions is perhaps even more strikingly shown here than in the case of Pelee Island. It should be recalled that the joint directions employed are the ones found on Pelee Island Whether or not they are the same as those which would be found on the Bass islands is unknown to the writer However, the apparent relationships shown in Figure 15 suggest not only that these would be found to be the principal joint directions there, but also that they are the controlling joint directions for the area, irrespective of what joint directions might be determined locally.

If the foregoing data are sufficient, as the writer believes they are, to establish the control by joints, the question then becomes: What is the agent (or agents) involved in the formation of the islands? Although the literature contains many papers upon the Erie basin, only one direct reference to the

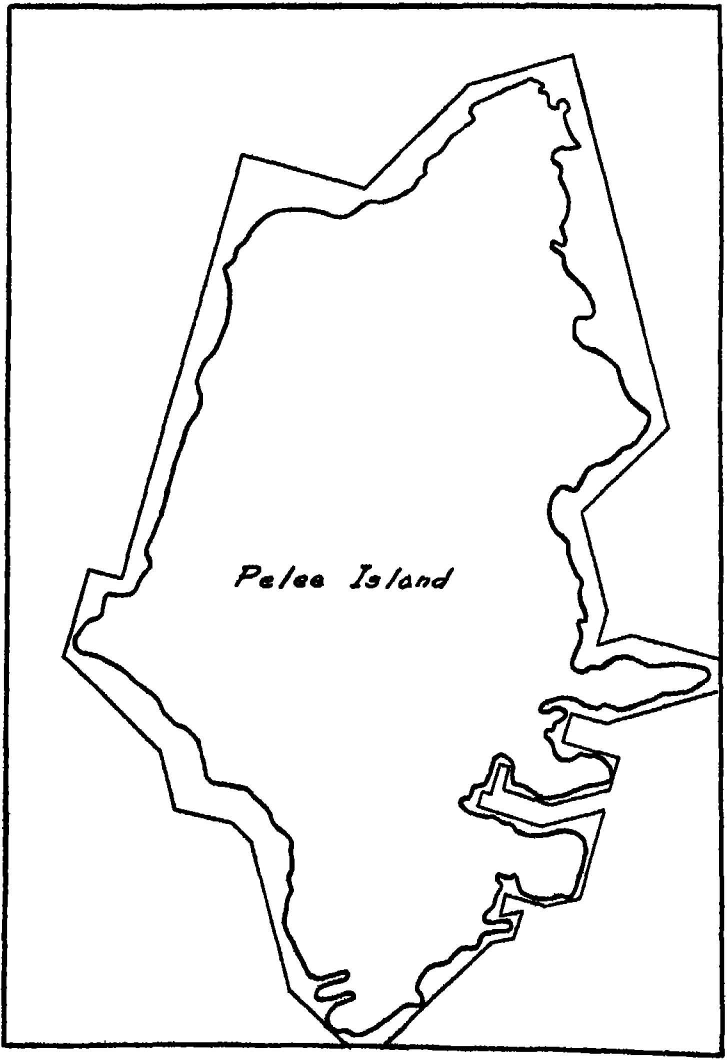

Fig 14, showing the 21-foot Depth-Line around Pelee Island

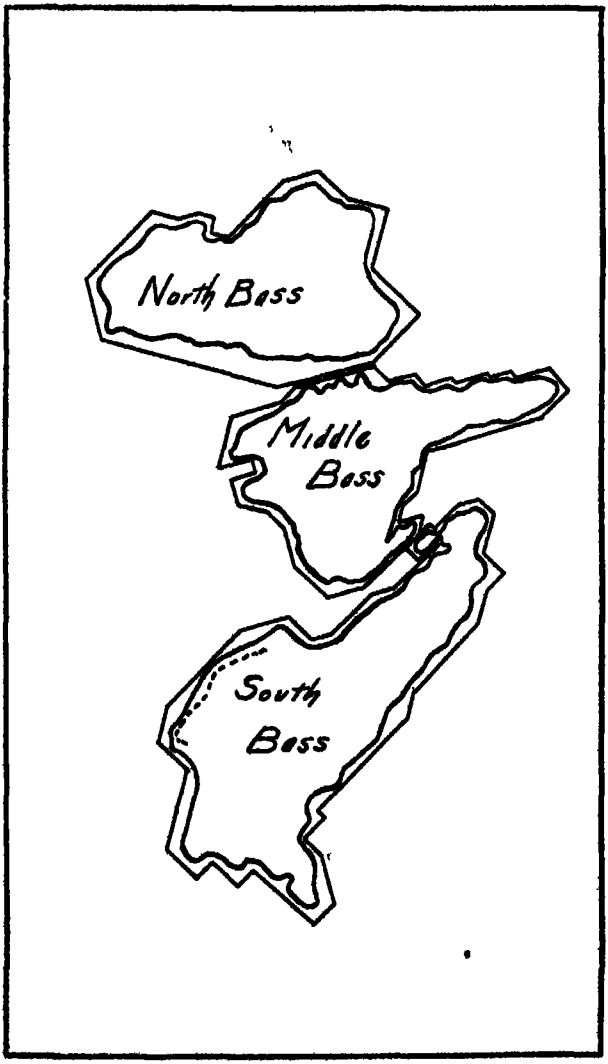

Fig. 15, showing the 21-foot Depth-Line around North Bass, Middle Bass and South Bass Islands formation of the islands has been found. Newberry[1] in 1874, after stating that the Laurentian Lakes occupy basins excavated in the plateau skirting the edge of the Canadian Highlands, the outlines of which have been "partially determined by upheaveal" and "at least partly excavated by a mass of moving ice," says "The islands at the western end of the lake (Erie) are remnants of hard Corniferous limestone beds raised in the line of the great Cincinnati anticlinal. These interposed considerable resistance to the action of the glacier and portions of them were left forming islands."

Any other ideas as to the origin of these islands must be inferred from statements regarding the origin of the Lake Erie basin. Thus, Lesley[2] in 1881, in discussing a paper presented by Newberry, stated that the glacier protected the Erie basin from erosion while it scratched the islands at the western end of the lake, thereby implying that the islands antedated the glacial period. In the same year, Claypole,[3] after attacking the glacial erosion theory, presented the river-erosion theory.

Also in the same year, Spencer[4] stated that three theories of the origin of the Laurentian Lake Basins had been advanced: "(1) the basins of the lakes are geological valleys; (2) the basins were excavated wholly or partly by glacier-action, (3) the basins were excavated by atmospheric and fluviatile erosion." He concludes with the statement: "The lake basins are valleys of subaerial and fluviatile erosion."

Later, Spencer[5] presented an elaboration of these views before the Geological Society of London. In commenting upon the paper Professor Seeley[6] said that he did not think that the ancient valleys had been excavated any more by rivers than by ice, but that the Laurentian Lakes followed the outcrops of the strata sufficiently to suggest that the lakes were originated by earth movements and that he believed that the main work of excavation was attributable to marine denudation

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[1] J. S. Newberry, *Proc. Lyc. Nat. His. Soc., N. Y., Second Ser.*, 1874, pp. 136–138.

[2] J. P. Lesley, *Proc. Am. Phil. Soc.*, XX (1881): 100.

[3] E. W. Claypole, *Proc. Am. Assoc. Adv. Sci.*, XXV (1881): 157.

[4] J. W. Spencer, *ibid.*, p. 131.

[5] *Quart. Journ. Geol. Soc. Lon.*, 46 (1890): 525.

[6] *Ibid.*, p. 533.

Of the four theories of the origin of the lake basins suggested, one, namely, that they are geological valleys, can scarcely be thought to apply to the origin of the Erie Basin The other three involve erosion, either by ice, running water or waves, and, although definitely stated only by Newberry, would imply that the islands at the western end of Lake Erie had been formed by some one of the agents. The consensus of opinion seems to be that stream erosion has played the most important part in the formation of the Erie Basin and therefore of the islands. The writer would like to suggest another possible origin for the islands, namely, faulting.

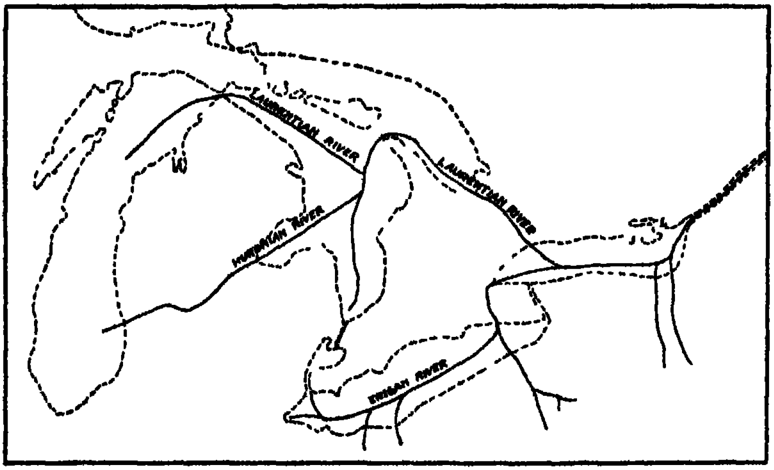

FIG. 16, showing Preglacial Drainage Lines (after Spencer)

Let us then consider the evidence in favor of each of these two theories.

Spencer[7] worked out a system of preglacial drainage lines (Fig. 16) for the area of the Great Lakes and subsequently a somewhat different system was worked out by Grabau[8] (Fig 17).

[7] J W Spencer, *Am. Geologist*, VII (1891) 78.

[8] A. W Grabau, *Bull. N. Y State Mus.*, 45· (1901). 44.

A comparison of these drainage plans with the joint directions observed on Pelee Island is interesting It is to be noted that in both instances there is a decided parallelism with some of these joint directions, although the drainage is quite different in the two plans

Spencer does not give any reason for the drainage plan which he presents Grabau, however, believes that the main streams, which trend approximately N 45° E., are consequent streams formed on a southwesterly sloping, Tertiary peneplain and that the subsequent branch streams which developed at right angles had their position fixed by the strike of the southwestward dipping strata. These Streams, therefore, had a general N. 45° W. trend.

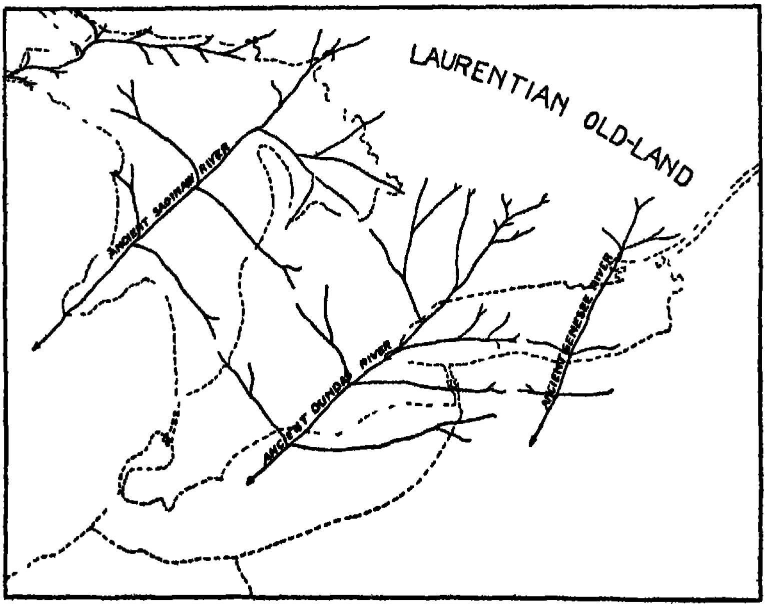

Fig. 17, showing Preglacial Drainage Lines (after Grabau)

It seems to the writer that these directions of the streams may have been determined, at least in part, by the principal joint directions or even by faults The drainage plan of Spencer, particularly at the eastern end of Lake Erie, is especially suggestive of this Even stronger evidence of joint or fault control of these preglacial streams is suggested by papers by Hobbs[9] and Pirsson,[10] both of which show that the present drainage lines in Ontario exhibit predominantly the N. 45° E and N 45° W trend, which they assign to joint or fault control. This parallelism of the present and preglacial drainage is suggestive of the same control in both instances

In support of the idea that faulting may have played a part in the formation of the islands at the western end of Lake Erie, the evidence must be largely circumstantial as no actual displacement of the beds has been observed There are, however, several lines of evidence strongly suggestive of faulting Coste[11] has stated that in the Gosfield gas field on the main land northwest of Pelee Island there is a fault trending west-northwest and another at right angles to it. These directions would correspond to the N 70° W and N. 15° E. set of joints.

Additional evidence of faulting is possibly afforded by the correlation of the unsatisfactory well logs available Thus it is found that in one of the wells drilled on one of the 'rock islands' to the south, gypsum appears at 660 feet and is absent below 740 feet, whereas in a well recently drilled between the 'rock islands' and where solid rock was not encountered until a depth of 125 feet had been reached, gypsum makes its first appearance at 890 feet

In conclusion it must be stated that at present the evidence is insufficient to determine the agent of formation with reasonable certainty The writer believes, however, that the evidence is amply sufficient to indicate the strong influence of joints, irrespective of the agent.

UNIVERSITY OF MICHIGAN

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[9] Wm. H Hobbs, *Wis. Acad Sci., Arts and Letters*, Vol 15 (1905), Plate III Also, *Bull Geol Soc Am*, Vol 22 (1910), Figs 25 and 26

[10] L V Pirsson, *Am Journ Sci*, Vol XXX (1910), Fig. 1, p. 26

[11] Eugene Coste, *Journ. Can. Min. Inst.*, 3. 74

# A "LACCOLITE IN THE AIR"

### LAURENCE M. GOULD

AFTER pointing out in his memorable monograph on the Henry Mountains that there are two zones of laccolites in these mountains, Gilbert[1] speculates upon the possibility of the southern mountains, which represent the lower zone, having formerly possessed laccolites of the upper zone He shows that if superior laccolites had existed, their removal by erosion would have been sure to leave behind them a record of the conduits through which their lava was injected. Naturally the discovery of such conduits, as for instance dikes, cannot be regarded as absolute proof of the former existence of a superior laccolite, but it demonstrates the possibility of such structures The summits and flanks of Mounts Holmes and Ellsworth have many dikes which have been regarded as subsidiary features of the laccolites beneath them, but Gilbert points out that it is quite possible 'that any one of them may formerly have led to another laccolite above But Gilbert finally concludes "Upon such uncertain evidence no positive conclusion can be based, and it is vain to build laccolites in the air"

In his studies in the La Sal Mountains of southeastern Utah, which lie about 85 miles north of east from the Henry Mountains, the writer has found what seems to be the exact structure which Gilbert had in mind by his "laccolite in the air."

The La Sal Mountains are divided into three groups separated by sedimentary saddles. The structure of the end-groups is fairly simple The magma was intruded into the Cutler or perhaps between the Cutler and the Rico, and the overlying beds were upturned. A great force and perhaps the major one

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[1] Gilbert, G. K., "Report on the Geology of the Henry Mountains," *U S. Geog. and Geol Survey of the Rocky Mt. Region* (1887), pp 58–59

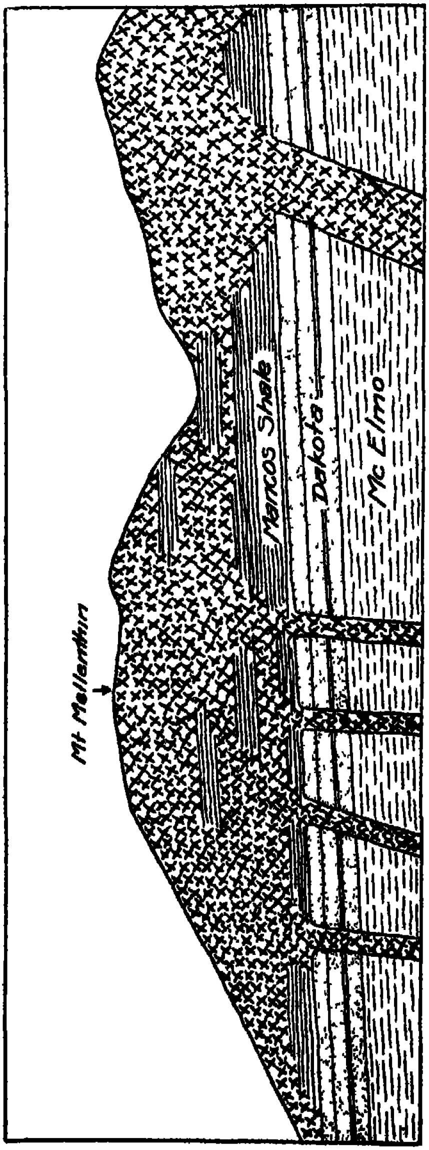

Fig 18 Diagrammatic Sketch to show the Structural Relationships at the head of Horse Canyon

in the doming of the strata over these end-groups was orogenic stresses in the nature of folding, for both these groups are intimately associated with anticlinal structures of the plateau country. In the central group there is no evidence that the intrusion was influenced by orogenic stresses and the structural features are more complex than in the end-groups Here there seem to have been two horizons of intrusion, one above the other The sediments are found to dip away from the center of this group at an angle of about 5 degrees When these dipping beds are followed to the igneous cores it is found that the main part of the igneous masses are above these strata Wherefore it appears that the doming of these strata has been induced by an intrusion not exposed In case of Mt Mellenthin of this group this suggestive relationship is clearly displayed One can stand on the west side of Horse Canyon which heads against the west side of this mountain, and look across the canyon to the east to a surprisingly perfect section of a "laccolite in the air" The dike feeders through which the magma rose are clearly exposed and can plainly be seen cutting upward through the McElmo and Dakota formations into the Mancos shales where the magma spread laterally and also domed up the superior beds The presence of masses of shale in the porphyry and the nature of the injection of the porphyry into the shales, together with a consideration of the attitude of some outcrops of this shale north of the mountains, indicate that the Mancos formerly constituted the cover of the mountain and may also have possessed small interbedded sheets of porphyry, which have since been eroded away Figure 18 is traced from a series of photographs taken from the side of Horse Canyon opposite Mt Mellenthin It not only shows the genetic relationships between the dikes and the main mountain mass, but it also shows how the floor of the mountain is dipping up toward the south. A careful study of the structure of this entire group indicates the probable existence of a buried laccolitic body below those now exposed The thickest portion of this buried mass lies near the center of the group or to the south of Mt. Mellenthin, hence the attitude of the beds exposed below the base of this mountain. A general survey of the structure of this group suggests that there are two horizons of intrusions — two zones of laccolites, one above the other after the fashion which Gilbert suggested may have formerly obtained in the southern laccolites of the Henry Mountains.

UNIVERSITY OF MICHIGAN

# THE CAUSE OF EARTHQUAKES

## ESPECIALLY THOSE OF THE EASTERN UNITED STATES

WILLIAM HERBERT HOBBS

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## PART I. GENERAL

### EARLY EARTHQUAKE THEORY

*Scriptural doctrine* — The Bible lands were among those racked by earthquake, and the explanation offered in the Bible was one common at the time, namely, that God was displeased with his creatures and was visiting punishment upon them The imagery of the Old Testament reflects this feeling "Thou hast made the earth to tremble, Thou hast broken it, heal the breaches thereof for it shaketh," is the description in the sixtieth Psalm. In the one hundred and fourteenth Psalm we read, "Tremble, thou earth, at the presence of the Lord, at the presence of the God of Jacob, which turneth the rock into a standing water, the flint into a fountain of waters," the fountains of water being a characteristic phenomenon of all earthquakes. and there follows the inevitable, "O God, . . Thou hast been displeased· O turn Thyself to us again."

*Aristotelian view* — The Greek philosophers were familiar with the earthquakes of the Mediterranean region and the view of Aristotle, endorsed as it was by the geographer Strabo, has come down to us, and with some slight modification it has survived in a quite modern theory which until within a score of years was regarded as standard doctrine. Aristotle conceived earthquakes to be brought about by air imprisoned within subterranean cavities, and by its struggles to escape this air caused a shaking of the ground. Regions where there were many caves, such as Achaea, Euboea and Sicily, were, as Aristotle well knew, especially subject to earthquakes.

The Aristotolian idea was well expressed by Shakespeare, who makes Hotspur say to the boastful Glendower:

> O then the earth shook to see the heavens on fire,
> And not in fear of your nativity
> Diseased nature oftentimes breaks forth

In strange eruptions, oft the teeming earth
Is with a kind of colic pinched and vexed
By the imprisoning of unruly wind
Within her womb, which, for enlargement striving,
Shakes the old beldam earth, and topples down
Steeples and moss-grown towers

The suggested connection of earthquakes with volcanoes in this passage from *Henry IV* has been common, as is clear from the almost hopeless confusion in most of the early writings which deal with earthquakes and volcanoes

*Von Humboldt's idea of safety-valves* — Alexander von Humbolt made the correct observation that although there were earthquakes usually connected with the eruptions of volcanoes, such earthquakes were by comparison with the devastating earthquakes of history relatively weak and insignificant He conceived the volcanoes to be, therefore, a sort of safety-valve for pent-up gas imprisoned within the earth, which following the Aristotelian view he believed to be the cause of earthquakes

*Modern dress of Aristotle's doctrine, Mallet, 1862* — The ancient view that earthquakes originate within a cavity or focus wherein gases are confined, was given a modern dress as a scientific theory by an Irishman, Robert Mallet, who had invented a new type of mortar and had also made investigations upon the life of guns These studies had brought him much renown and had been of the greatest service to the Allies during the Crimean War of 1854–1855 When, therefore, in 1857 an earthquake devastated the kingdom of Naples, Mallet applied to the Royal Society for a grant of money for the purpose of making a study of this earthquake. Apparently under the impression that an expert upon explosives was by his training best qualified to study an earthquake, the Society readily granted his request, and the results of his study were later published in two massive volumes bearing the title *The Neapolitan Earthquake of 1857*. When Mallet undertook this study the science of physics had recently been much advanced by the Dutch physicist Huygens, who had introduced a new method for following the progress of harmonic disturbances travelling through media such as light through glass or sound through air. Mallet adapted this scientific method to a study of the progress of earthquakes through the outer layers of the earth, and he further supplied technical names which have been widely employed even since his theory has been discredited The supposed cavity or focus within which the shocks were supposed to originate, Mallet called the *centrum*, and the point upon the earth's surface directly above it he named the *epicentrum*, at which point the shocks were believed to arrive first and to be of the greatest intensity This scientific dress applied to Aristotle's theory accounted for its retention by scientists as orthodox doctrine for another fifty years, or until early in the twentieth century

## THE UNIQUE FAULT THEORY

*Japanese earthquake of 1891, Kotô, 1893* — Scientists are now well agreed that gases imprisoned within the earth are not the cause of the devastating earthquakes, though they may perhaps in part explain the relatively insignificant shocks which occur in connection with eruptions of certain volcanoes Students of earthquakes are also in accord in believing that earthquake shocks are in some way connected with the formation of breaks and resulting displacements of the rocks at and near the surface of the earth. This change of viewpoint has come about from studies of earthquakes which have occurred within the last third of a century

The great earthquake of 1891 in the Neo Valley of Japan was the first to supply striking photographs of changes produced at such times in the surface of the earth, and these photographs came quite generally into the hands of scientists[1] Though they produced a profound impression they did not immediately discredit the centrum theory. The pictures showed that for many miles across the country a fracture of the ground appeared at the time of the earthquake, and that along this fracture the land upon one side had been raised relatively to that upon the other by as much as eighteen feet at one place; while at other places though neither side had been raised or lowered in reference to the other, the two sides of the displacement had slipped past each other in opposite directions along the surface of the ground a distance of the same order of magnitude as that shown by the vertical displacement. It did not admit of doubt that these scissor-like movements of the ground, whether up or down or along the surface, had been sudden and violent and had, moreover, been connected with the jolting movements to which the term earthquake had been applied.[2]

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[1] John Milne and W K Burton, Professors in the Imperial University, *The Great Earthquake in Japan, 1891*, 30 photogravures, plates, and map with descriptions. Lane, Crawford and Co , Yokohama (no date).

*Hindustan earthquake of 1897, Oldham, 1899* — Six years later occurred the great Assam (Hindustan) earthquake which was also carefully studied.[3] In this case though a small part only of the affected area was examined, there were found no less than three fracture displacements (faults), and the maximum vertical displacement measured was about thirty-five feet The likelihood is that a number of other faults were produced at the surface, though the localities were not visited by any representatives of the scientific personnel of the Indian Survey Stress was, however, laid upon *one* plane only of fracture and displacement, and this was believed by Oldham to be a thrust on a plane of low angle to the horizon.

### THE THEORY OF MOUNTAIN GROWTH, DE MONTESSUS, 1906

*Two earthquake girdles* — The late Count de Montessus de Ballore published in 1906 the results of an exhaustive study of the distribution of earthquakes, as a result of which he reached this conclusion

> The earth's crust quakes almost in equal amounts and almost entirely along two straight zones which lie along two great circles (in the geometric sense) which make an angle with each other of about 67° — the Mediterranean or Alps-Caucasus-Himalaya circle (53 54 per cent of the earthquakes), and the circum-Pacific or Andes-Japan-Malay circle (41 08 per cent of the quakes) These two zones correspond with the two most important lines of relief of the terrestial surface (Fig. 19).

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[2] B Kotô, "On the Cause of the Great Earthquake in Central Japan, 1891," *Journ. College Sci. Imp Univ.*, Tokyo, vol. 5, 1893, pp 295–355, pls. 28–35

[3] R. D Oldham, "Report on the Great Earthquake of 12th June, 1897," *Mem. Geol. Surv India*, Calcutta, vol. 29, 1899, pp. 379, pls 42, maps.

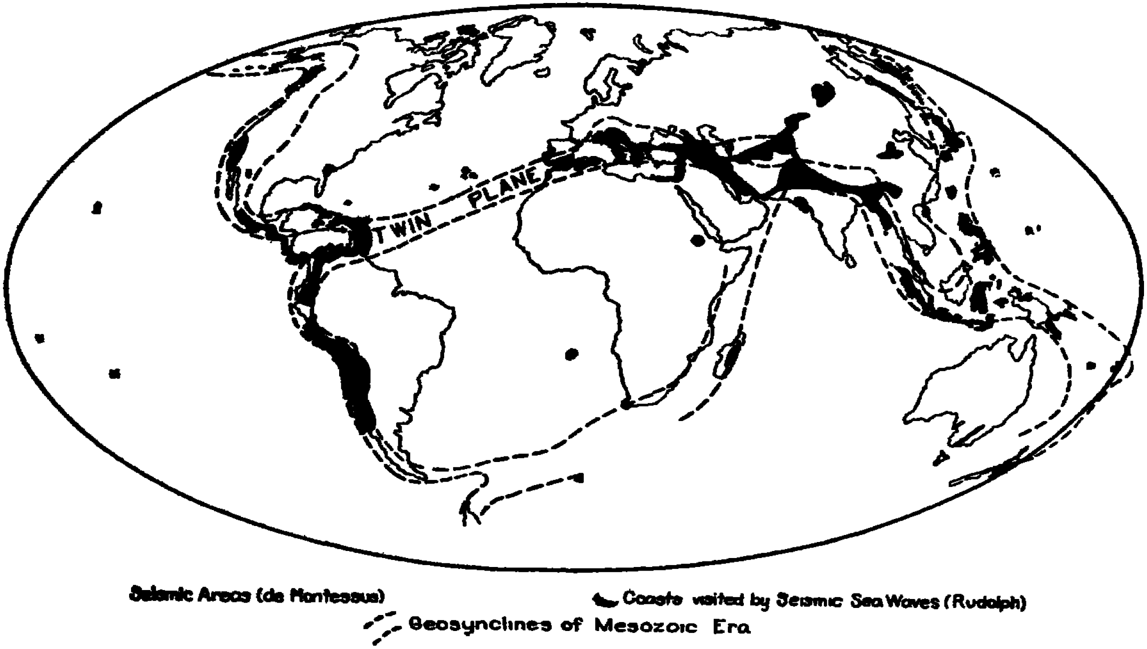
TWIN PLANE
Seismic Areas (de Montessus)
Coasts visited by Seismic Sea Waves (Rudolph)
Geosynclines of Mesozoic Era

FIG. 19 Map by De Montessus to show the earthquake girdles, but reduced to the Mollweide projection

*Mesozoic geosynclines* — Dr. de Montessus furthur concluded

> The zones, the seismic regions, coincide exactly with the geosynclines of the Secondary epoch
>
> The geosynclines — the most mobile bands of the earth's surface — where the sediments have been deposited in the greatest thickness, have been energetically folded, dislocated and elevated in the Tertiary epoch, at the time of the formation of the principal existing mountain chains, including *within themselves, with two or three doubtful exceptions, nearly all* the seismic regions, which in consequence characterize them
>
> The folded architecture of the geosynclines is unstable, in contrast to the tabular architecture of the continental areas, and this has with much probability been true of all the geological epochs[4]

We have here, then, a very clear statement that the earth's two zones of earthquake of the present time, including together as they do 94 62 per cent of all recorded earthquakes upon the land areas, are the zones within which the thickest lenses of sediments were deposited during the Mesozoic era, and where also, beginning in late Cretaceous or Tertiary time, ranges of mountains have been in process of erection It is further pointed out that this zone of folding is much dislocated

### ADJUSTMENTS WITHIN A FAULT MOSAIC AS COROLLARY TO MOUNTAIN GROWTH

*Tarr and Martin, 1906* — In 1899 Thoroddsen printed in the *Icelandic Language* an account of the earthquakes which occurred in Southern Iceland in 1896, and in which five separate earthquakes had shaken in succession each of five contiguous earth blocks[5] In 1906 Tarr and Martin[6] clearly demonstrated that the earthquake of 1899 along the base of Mt St Elias was a renewal of mountain growth along the shore of the Yakutat Bay in which large vertical adjustments measured in ten's of feet took place between the large blocks within a fault mosaic, and that movements of smaller magnitude occurred between smaller blocks which were parts of the larger and composite ones. This study is therefore one of the most important and satisfactory that has ever been made of a great earthquake.

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[4] F de Montessus de Ballore, "Les Tremblements de Terre," *Géographie Séismologique*, Colin, Paris, 1906, pp 24–25

[5] A German abstract of Th Thoroddsen's paper appeared in vol 47 (1901) of Petermann's *Mitteilungen*

[6] R S Tarr and L Martin, "Recent Changes of Level in the Yakutat Bay Region, Alaska," *Bull Geol. Soc. Am*, vol 17, May, 1906, pp 29–64, pls. 12–23.

*Hobbs, 1907* — In 1905 the writer carried out a comprehensive study of the great Calabrian earthquake of that year with the result of showing that even where actual faults are not disclosed by escarpments or other displacements at the surface of the ground, their course may be followed often in great numbers as *seismotectonic lines* — lines of heavy shock[7] These lines, as the examination of earlier earthquakes within this much-racked province clearly showed, have been repeatedly the seats of movement. In the same year the writer pointed out in a discussion of seismic sea-waves that these indicate a deepening of trenches on the sea floor at the time of such waves, when the neighboring coasts are usually elevated To cite

> Such depressions of the deeps and uplifts of the neighboring shores probably stand in some sort of balance, and both alike call for an initial recession of the water from all near-lying shores toward the area of depression at that instant when the movement occurs. Such a mass of water as would pile up over the depressed area of the sea-floor as a result of the inrush of water from all sides, should be later spread in all directions and roll in to inundate the shores[8]

At the time it was written this explanation seemed to call for mass movements upon the floor of the sea too large for ready acceptance by geologists, and the view appeared to find little support. Sixteen years later, nothing daunted, the writer had the temerity to state his belief that "the floor of the ocean has undergone sudden changes of elevation measured not in tens of feet, as have the zones of unrest upon the continents, but rather in hundreds and even thousands of feet"[9] Within a few

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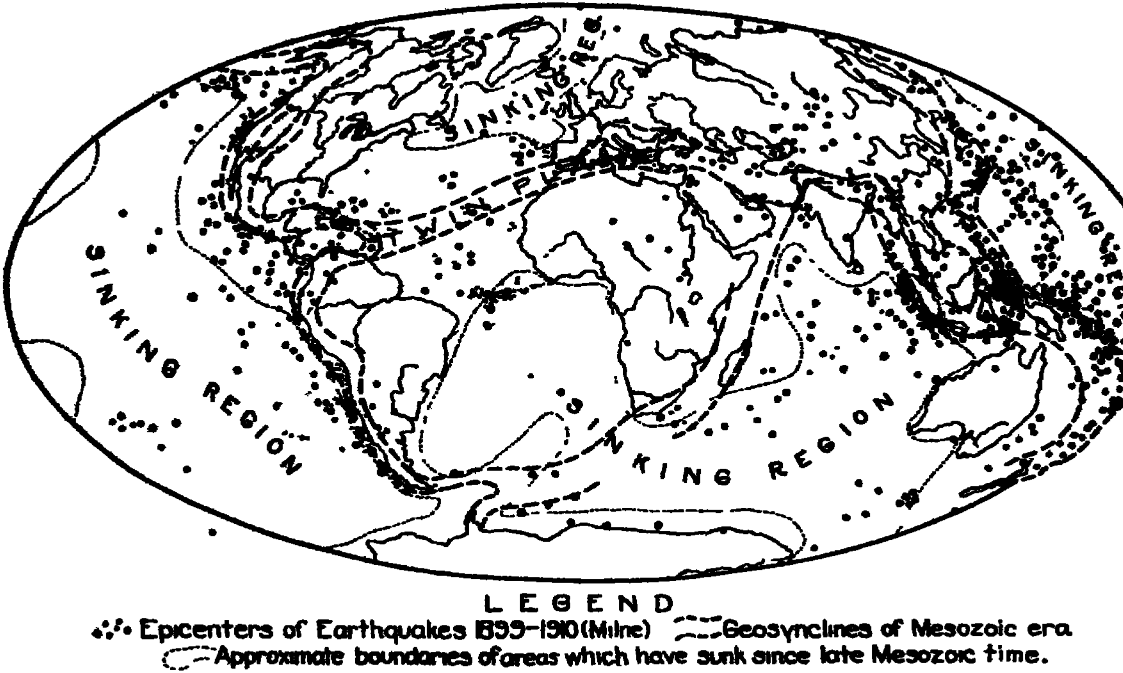
[7] William Herbert Hobbs, "On Some Principles of Seismic Geology, with an Introduction by Eduard Suess," *Gerlands Beiträge zur Geophysik*, Leipsig, vol. 8, 1907, pp 217–292, pl 1 and 10 figs "The Geotectonic and Geodynamic Aspects of Calabria and Northeastern Sicily, a Study in Orientation, with an Introduction by the Count de Montessus de Ballore," *ibid*, pp 293–362, 10 pls and 3 figs

[8] W H. Hobbs, *Earthquakes, an Introduction to Seismic Geology*, Appleton, 1907, chap. XV, especially pp 253–254

[9] "The Rate of Movement in Vertical Earth Adjustments Connected with the Growth of Mountains," *Proc Am Phil Soc*, vol. 62, 1923, p 70.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LEGEND
Epicenters of Earthquakes 1899–1910 (Milne)
Geosynclines of Mesozoic era
Approximate boundaries of areas which have sunk since late Mesozoic time.

FIG 20 World map of earthquake distribution for the period 1899–1910, made from data assembled by the British Association, but transferred to the Mollweide projection

months came the great Japanese earthquake in connection with which there occurred a seismic sea-wave, an elevated coast, and a sudden adjustment of the floor of Sagami Bay off the coast The volume of the area dropped measured some 50 cubic kilometers and the amount of the drop measured over large areas 50 fathoms or more (300 feet) [10]

*Willard D Johnson, 1907-1910* — In the early spring of 1907 at the writer's suggestion Mr Willard D Johnson undertook a field-study of the scene of the Owens Valley earthquake of 1872 This occurred within a desert region of California in which the dislocations had suffered little change in aspect within the subsequent thirty-eight years For the first time in history an accurate map was prepared of a fault network which had suffered a mosaic-like adjustment at the time of an earthquake [11]

*Seismic World Map, 1915* — The map of the unstable regions of the earth's outer shell which had been issued by De Montessus in 1906, reveals two narrow great-circle girdles (see p 262, Fig 19) The introduction of instrumental methods with use of the modern seismograph has enabled seismologists to extend their studies to the floor of the oceans The Seismological Committee of the British Association published in 1916 a comprehensive world map of great earthquakes instrumentally located for a ten-year period (1899–1910) [12] This map (Fig 20) upon a quite different basis confirmed that of De Montessus concerning the twin girdles, but showed that these zones extend outward from the margins of the continents into the sea and include the trough-deeps upon the sea floor. The zone of maximum instability, moreover, corresponds to the steep slope which joins the mountain arcs of the coasts and islands to the deeps which lie parallel to them The identity of these special earthquake girdles with belts of mountain growth — of wrinkled formations upon the earth's surface — seems thus to be confirmed from a new quarter

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[10] A. Imamura, "Preliminary Note on the Great Earthquake of S E Japan on Sept. 1, 1923," *Seismological Notes*, No 6, Imp Earthq Invest. Comm., Tokyo, July, 1924, p 16, pl 4 T Kato, "Preliminary Notes on the Kwanto Earthquake in Japan, September 1, 1923," *Journ Geol Soc. Tokyo*, vol 30, No 361, p 8

[11] W. H Hobbs, "The Earthquake of 1872 in the Owens Valley, California," *Gerlands Beiträge zur Geophysik*, vol 10, Leipzig, 1910, pp 351–384, pls. X–XXIII (Read before the Association of American Geographers at Chicago, December, 1907)

[12] H. H Turner, and others, *20th Rept Seismol Comm*, *Rept. Brit. Asso*, Manchester meeting (1915) 1916, pp. 52–79, pl 1.

*Magma Pocket below and vent above earth-wrinkles* — Geologists no longer generally believe, as formerly they did, that the earth's interior is molten The source of the molten rock (magma or lava) which issues from active volcanoes is now believed to come from reservoirs which are relatively small. There are grounds for believing that these reservoirs are located beneath the arches of the mountains Though the earth's interior is believed to be hot enough to melt the rock were it at the surface of the earth and under air pressure only, the rock is believed to be kept rigid by the load upon it The formation of the wrinkle at the surface of the earth lifts this load and thus permits a magma reservoir to form beneath it, and above this reservoir the volcanoes naturally develop [13]

*Omori's law of geographical succession of earthquakes within girdles* — The late Professor Omori, distinguished Japanese seismologist, has given his adhesion to the view that the earthquakes within the great girdles of the earth are connected with mountain growth It was in 1907 in his report upon the California earthquake that he called attention to the geographical order of succession of earthquakes within the earthquake girdles An earthquake which occurs within any section of one of the girdles may be regarded as relieving the strain by transforming potential into actual energy, this relief being partial only beyond the area characterized by heavy shocks The greatest probability of an impending earthquake applies, therefore, to those sections of the girdle which are farthest removed from regions of recent relief

*Earthquake prediction* — Upon this assumption after the California earthquake in 1906, Professor Omori predicted on August 4, 1906, just before he sailed for Japan that the next earthquakes within the circum-Pacific girdle would probably occur south of the equator — in South America. Before his ship had reached Japan occurred the great Valparaiso (Chile) earthquake of August 17, and upon the same day the great Aleutian (Alaska) earthquake.[14]

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[13] *Earth Evolution and Its Facial Expression*, 1921, chaps 3–5

Utilizing the Omori suggestion, the writer in 1909 predicted that "the zone in which the probability of heavy shocks is now most imminent, are the Japan-Kamchatka segment, the Peru-Bolivia segment, and the archipelago region to the southeast of Asia." [15] (See Fig 21 )

The mountain range does not, so far as our knowledge goes, appear to be forming throughout the circuit of the great circle hemming in the Pacific, but terminates in West Antartica and in New Zealand. It is in the New Zealand region, particularly, that future shocks may be looked for Tokyo was largely destroyed by earthquake in 1855 and again in 1923 A heavy earthquake visited the vicinity of Wellington, New Zealand, in 1855, producing a fault scarp which may still be followed at the surface, and it is reasonable to suppose that a recurrence of movement in this neighborhood will take place in the not distant future

After the meetings of the Second Pan-Pacific Science Congress held in Australia in 1923 and just before his lamented death, Professor Omori travelled in the writer's company from Sydney to Honolulu Referring to the great Tokyo earthquake which had occurred less than a fortnight before, Professor Omori told the writer that he had fully expected this earthquake to take place within the Tokyo region, though not for another fifty years This statement of his illustrates well the possibilities of a fair prediction of earthquakes as to their general locality, at the same time that it exposes our limitations with respect to the time of arrival of these devastating visitations.

## ELASTIC REBOUND THEORY OF REID, 1910

*Theory stated.* — When in 1906 America was first awakened to the understanding that an earthquake peril exists upon its Pa-

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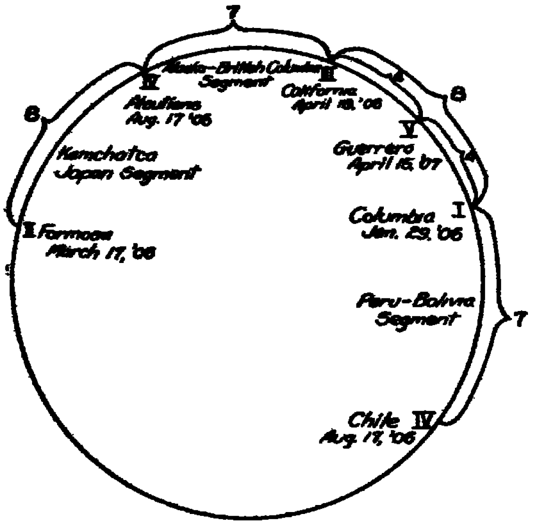
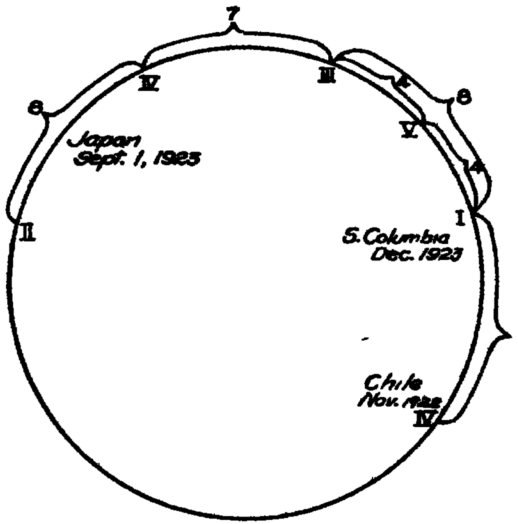
[14] F Omori, "Preliminary Note on the Cause of the San Francisco Earthquake of April 18, 1906, "*Bull Imp Earthq Inves. Comm.*, vol 1, no 1, Jan , 1907, pp 21-25 For later expression of this view see "Earthquake Zones in and around the Pacific," *ibid* , vol 11, no 1, 1923, pp. 28-32

[15] "The Evolution and the Outlook of Seismic Geology," *Proc Am Phil. Soc* , vol 48, July 6, 1909, p. 32



1906-1907

Fig 21 A



1922-1923

Fig. 21 B

Fig 21 A. Reproduction of the writer's map published in 1909 to show the sequence of recent earthquakes at that time

Fig 21 B Map showing positions of subsequent large earthquakes

cific Coast, it had few scientists who possessed a background of earthquake lore, as had, for example, the Mediterranean countries of Europe and Japan It is unfortunate, therefore, that those who came to be charged with the investigation of this earthquake did not endeavor to study the literature of the subject before writing the report and supplying a theory of cause [16] Reid's theory of elastic rebound is based upon the assumption that there was a single line of dislocation — the visible San Andreas rift or fault — and that the displacement along this plane was entirely in a horizontal direction, the area to the westward being supposed to shear upon that to the eastward This shearing strain, generated, according to the assumption, as the result of a current or of currents within the subcrustal region on directions parallel to the San Andreas rift, dragged, it was believed, the overlying crust along with them The strain so set up was believed to be relieved through rebound on the fault plane at the instant of the earthquake [17] This theory has been further developed by Lawson under the name "crustal creep and elastic rebound" theory [18]

*Its inadequacy* — As already pointed out, the elastic rebound theory of earthquakes is a reversion to the notion that within any district an earthquake is the result of a slip on a unique plane of faulting, and this new theory was set up without any apparent attempt to fit it to other earthquakes Evidence of vertical, as well as horizontal, displacement along the San Andreas rift was, however, to be noted especially at Skinner's Range where the writer among many others examined it It is perhaps true that the revealed displacements upon the San Andreas rift were proportionately more largely horizontal than in the case of many other earthquakes, but lateral displacements of the same order of magnitude combined with large vertical displacements were measured, for example, in connection with the Japanese earthquake of 1891 and the Owens Valley earthquake of 1872. One of the most striking things about earthquakes is the almost monotonous uniformity observed in the nature of the phenomena which accompany them

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[16] See *Bull Geol Soc. Am*, vol 32, 1921, p 45

[17] H F Reid, "On Mass Movements in Tectonic Earthquakes and the Depth of the Focus," *Gerlands Beitr z Geophysik*, Leipzig, vol 10, 1910, pp 318–351, also, *Rept State Earthq Invest Comm.* (Carneg Inst, Wash), vol 2, 1910, also, "The Elastic Rebound Theory of Earthquakes," *Bull. Dept. Geol, Univ Calif, Pub*, vol 6, 1911, pp 413–444

[18] A C Lawson, "The Mobility of the Coast Ranges of California, an Exploitation of the Elastic Rebound Theory," *Bull Dept Geol, Univ Calif. Pub*, vol. 12, no 7, 1921, pp 431–473, 19 text-figs.

Now that geodetic observations have been completed over a sufficient area of the southwestern United States to determine changes of position of triangulation stations since the locations made before the earthquake of 1906, it has been learned that these movements have been quite different from those claimed in the California report to have taken place. The maximum movement recorded is now found to be, moreover, not even within the region of the San Andreas rift Thus the elastic rebound theory of earthquakes, far from explaining earthquakes generally, cannot be made to fit the facts for the one earthquake to which it was originally applied [19]

*Sekiya's wires* -- Many years ago Professor S Sekiya undertook to represent the sequence of directions of shock received at his earthquake station during a single earthquake with the result of showing that so complex are these motions that to represent their directions and successions by a bent wire, it was necessary to employ three complicated snarls of wire in order to cover a minute only of time Such a result favors strongly the view that not one fault slip but very many on differently placed surfaces are the cause of the earthquake phenomena.[20]

## GENERAL STATEMENT OF PROBABLE CAUSE OF EARTHQUAKES

*Proximate cause.* — The proximate cause, or in common language the occasion, of earthquakes, so far as they occur within the earthquake girdles of the earth, would seem to be the formation of a fold or flexure within near-surface earth strata, such flexure being incident to the erection of a range of growing mountains of scalloped pattern accompanied by a series of parallel deep-troughs Such elevation of a mountain range is accompanied as a natural consequence by pockets of lava beneath the arch, and above these are formed a series of vents for the escape of the volcanic materials, both molten rock and gases.

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[19] Arthur L Day, "The Study of Earth Movements in California," Address of the President of the Washington Academy of Science, Jan 13, 1925. *Science*, vol. 71, no 1578, March 27, 1925, p 325

[20] S Sekiya, "A Model to Show the Motion of an Earth Particle during an Earthquake," *Trans. Seis Soc Japan*, vol 11, 1887, pp 175–177, pls 1–2.

If we omit the special characteristics, the proximate cause of earthquakes may be stated to be adjustments which take place in position or inclination of portions of the outer shell of the earth, and this broad general statement may be applied outside as well as inside the earth's earthquake girdles Such adjustment on the basis of many observations implies many individual movements among blocks composing a fault-mosaic

*Ultimate cause.* — The ultimate cause of earthquakes, the deep-seated reason for the changes brought about in the configuration of the earth's surface, is by geologists generally believed to be the continuous loss into surrounding space of the heat from the earth's interior portions This loss of heat is accompanied by a reduction of volume, a shrinking of the interior core of the earth, and the outer shell of rock being already cooled to a relatively stable condition must wrinkle as it adjusts itself The old illustration of an apple in late winter which wrinkles from the loss of water and consequent reduction of volume of its interior portion, may still serve well at the present time.

## PART II. EARTHQUAKES OF THE EASTERN UNITED STATES

### THE REGION A RELATIVELY STABLE ONE

*Historical earthquakes of the region* — Northeastern North America lies outside the seismic girdles of the earth (see Fig. 20 p. 265) and at least since its settlement by Europeans it has relatively seldom been vexed by destructive earthquakes That light shocks have not been infrequent within recent times, or since newspapers and the telegraph have been widely distributed, is, however, evident from compilations made by Rockwood.[21] In the state of Michigan alone within this period some ten earthquakes have been put on record, the latest of which occured February 28, 1925[22] Contrary to general opinion earthquakes of devastating violence have also visited the region of the eastern United States These greater earthquakes have seemed to have relation especially to the drainage basin of the Saint Lawrence River and Great Lakes, to the lower Mississippi region of heavy deposition, or to the coastal plain east of the Appalachian Mountains. Accounts made between 1610 and 1791 by the French Jesuit missionaries from within the area reached by canoes about the St Lawrence River and lakes, show that earthquakes were felt within that region in 1638, 1661, 1663, 1664, 1665, 1668, and 1672, that of February 5, 1663, described in the letters of Jerome Lallemant having been of devastating violence and probably comparable to the greatest earthquakes that are known The full accounts of the missionaries translated and edited under the direction of the late Reuben G Thwaites and published in seventy-three volumes by Burrows Brothers of Cleveland, have been searched for earthquake data and the extracted results published by Rev Father Odenbach of Cleveland[23]

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[21] C. G. Rockwood, fourteen articles in *Am. Journ. Sci.*, from 1872 to 1885.

In 1811 within the lower Mississippi Valley a really great earthquake generally referred to as the New Madrid earthquake was felt over a relatively broad area of the Mississippi Valley. For more than a century the region has now been generally quiet, but the scars of the disastrous disturbances of 1811 still arrest the attention, and this earthquake must be reckoned among the most severe of any that have been anywhere recorded.[24]

The Charleston earthquake of 1886, while of greatest intensity in the vicinity of that Southern city, was felt as far north as the City of New York[25] All three of these great disturbances of the eastern United States were within areas far outside the seismic girdles which mark the earth's zones of special instability

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[22] W. H Hobbs, "Earthquakes in Michigan," Pub 5 (*Geol Ser* 3), *Mich Geol and Biol. Surv*, Lansing, 1911, pp 69–87, 2 pls

[23] *Twelfth Ann Rept Meteorol Observ*, Coll St Ignatius at Cleveland, Ohio, 1906–1907, pp 7–15 For an abridged summary see the author's *Earthquakes*, Appleton, 1907, pp. 315–320 Lawson seems to be quite unaware of this earthquake (*Bull. Seis Soc. Am*, p 139, — reprints indicate no volume or date)

[24] Myron L Fuller, "The New Madrid Earthquake," Bull 494, *U. S. Geol. Surv.*, 1912, pp. 119, pls 10, figs. 18.

If we look upon the earthquake of the late seventeenth century within and about the St Lawrence drainage basin as more or less completely relieving the strains which had quietly been accumulating within that area, and much less completely the outside areas characterized by lighter shocks, then the New Madrid earthquake of a century and a half later may be considered to have accomplished a similar result for the large area to the south and west, the valley of the lower Mississippi Three-quarters of a century now elapse and the residue of the broad area, that to the south and east, finds relief during the earthquake of Charleston in 1886, with some relief also within the outlying areas where no destructive shocks, but only jars and tremors, were felt

Geological evidence is available from within the destructive area of the New Madrid earthquake, to show that an earthquake of devastating intensity and comparable in this respect with that of 1811, visited the region at least one hundred years earlier Altogether, then, we have the evidence that at intervals averaging a century or more, this broad region of eastern North America, usually looked upon as especially favored by its stability, has been visited by racking earthquakes of the first importance It is therefore necessary today to modify in a measure the views which have been generally held concerning earthquake distribution The fact that the settlement of America by Europeans came so recently, and that of the three great earthquakes known from the region, two belong to the early period of sparse settlement, pioneer scientific method, and imperfect historical record, largely explain the failure to assign proper values to these really great earthquakes

*Epeirogenic earthquakes of De Montessus* — Dr de Montessus in a magistrale posthumous work which came from the press in

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[25] C E Dutton, "The Charleston Earthquake of August 31, 1886," *Ninth Ann. Rept U S Geol Surv*, 1889, pp 203–528

1924, has described a new class of earthquakes for such regions as lie outside the earthquake girdles These earthquakes he ascribes to epeirogenic movements, up-and-down movements of neighboring sections of the earth's surface layers — and hence block movements which are unassociated with the folding process, as are those which occur within the earthquake girdles[26] In this he clearly recognized that his two earlier volumes through laying especial stress upon the importance of the two earthquake girdles, ascribed far too little importance to those earthquakes which occur outside

It is easy to account for the earthquakes of the lower Mississippi Valley through the gradually accumulating load over the delta region and the lower flood-plain of this great river. It has been estimated upon good authority that 513 million tons of suspended matter are carried out each year to tidewater in Louisiana, and this takes no account of the vast load that is laid down within the broad area of the flood-plain in the states of Arkansas, Missouri, Tennessee, Mississippi and Louisiana

Coastal changes of level, which though extremely slow are yet recorded in the uplifted terraces of wide tread and small rise along the Atlantic coast of the country, may account for the Charleston earthquake of 1886 and the many light earthquakes felt along the Atlantic seaboard A no less apparent cause for adjustment of the outer shell of the earth relates to the area of the Laurentian Great Lakes, and here fortunately we have a much greater body of evidence at our disposal

*Epeirogenic adjustments within Great Lakes area* — During the latest — and present — geological period, the Pleistocene, continental glaciers of an estimated thickness of between one and two miles, for a portion of the time lay over northern America so as to cover at their culmination the greater part of the area east of the Rocky Mountains and north of the Missouri and Ohio rivers Such a burden of ice must be conceived to have brought about a depression of the earth's surface within the region, from which recovery would presumably be either wholly or partially obtained when the ice waned and finally disappeared The evidence is conclusive that since the retirement northward of the latest continental glacier, the Laurentian drainage region has been undergoing an elevation which began toward the southern margin, has increased in amount toward the north, and is still continuing today at a somewhat rapid rate

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[26] F de Montessus de Ballore, *La Géologie Sismologique, les Tremblements de Terre*, Colin, Paris, 1924, chap I.

There is an extensive literature of the subject [27] as regards the nature of the evidence of uplift, but the explanation of the earthquakes of the region as a consequence of this uplift and uptilt of the land was, so far as he is aware, first made by the writer in two related papers published in 1911 [28]

Summarized for the general reader, the available data which prove the uplift and uptilt of the Laurentian basin relate (1) to the evidence of already accomplished movement, and (2) to the evidence that this upward movement still continues and so may be invoked to explain the earthquakes within the region

The evidence of the already accomplished uplift and uptilt is derived from the present positions and inclinations of the now abandoned shore-lines of the system of great ice-dammed lakes which lay along the front of the continental glacier during its retreat These shore-lines, which were of course horizontal when first formed, are now tilted upward toward the north at angles which increase rather rapidly as one proceeds north The uptilt has been likened to that of a trapdoor in the floor rotating upon its hinge, the hinge-line for the Laurentian region taking an average direction in the neighborhood of the Great Lakes of about 15° to the north of west The case is, however, not quite so simple as this, for the main hinge-line of the region has itself migrated northward since the beginning of the uptilt, and secondary hinge-lines within the trapdoor itself appear also to have functioned. One may liken the complex movement in its main lines to that of a trapdoor made up of several planks all parallel to the main hinge and each hinged to its neighbors, all hinges being or having been in action (Fig 22)

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[27] The more important series of papers are by Gilbert, Leverett, Taylor and Goldthwait.

[28] "The Later Glacial and Post Glacial Uplift of the Michigan Basin; Earthquakes in Michigan," *Mich Geol. and Biol Surv*, Pub. 5 (*Geol. Ser* 3), Lansing, 1911, pp 87, pls. 2 and 3, and figs 48 and 5.

We are now chiefly concerned, however, with the evidence

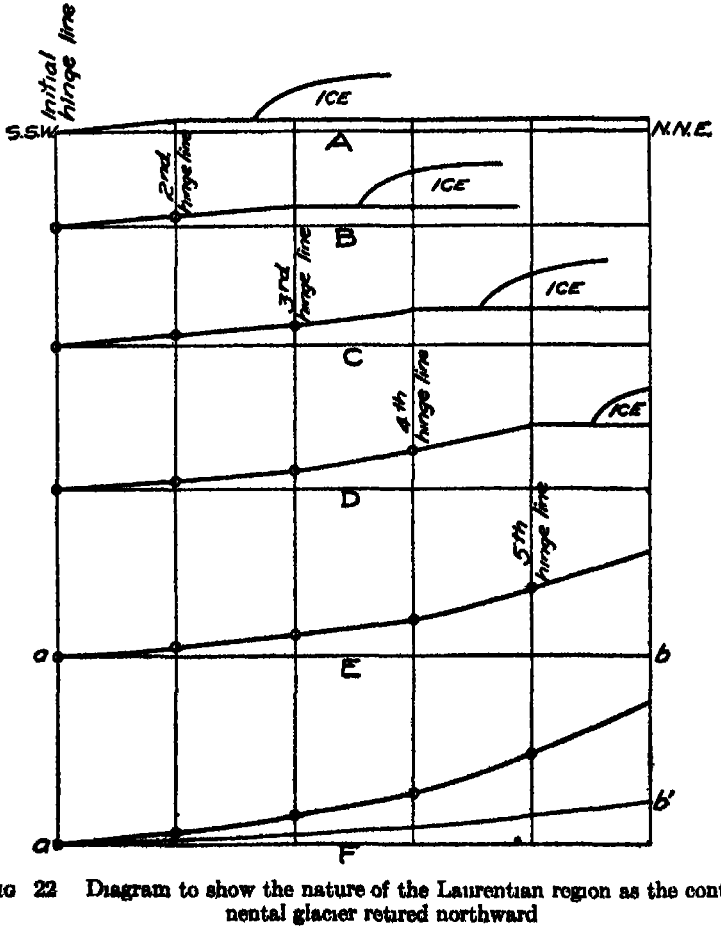

FIG 22 Diagram to show the nature of the Laurentian region as the continental glacier retired northward

that uptilt of the land is still going on, and may therefore be responsible for the earthquakes of the region The earliest clear recognition of such present-day uptilt was made by a land surveyor of Wisconsin, Mr G K. Stuntz, who in 1870 published a brief paper on observations made by him in the years 1852 and 1853 about Lake Superior.[29] Stuntz had noticed that on the northern shore of Lake Superior there were evidences that the land had recently risen, whereas on the south shore there were as clear signs of recent overflow It was as though one were to take in the hands a partly filled basin of water and by tilting it cause the water to withdraw from one side, where in consequence the bottom of the basin rises out of the water, and to flood the opposite side. Additional observations from Lake Superior which confirmed these observations by Stuntz were made by Lawson in 1891[30] The attention of geologists was first strongly directed to this tilting by Gilbert in 1898, when he investigated the series of records of the several gauging stations about the Great Lakes and found additional confirmation of the uptilt[31]

Upon the south side of Lake Superior in Michigan the evidences are especially easy to read The rivers of this coast have estuaries especially marked in the stretch from Ontonagon westward At some points in the Porcupine Mountain district the trees along the shore of the lake stand six to eight feet out from the shore in six to eight inches of water At other points where the trees are at the shores, the waves are beating against them and removing the bark Here the lake has already encroached upon roads so that they have had to be abandoned.[32]

Evidences of a somewhat similar nature to those found characteristic of Lake Superior belong also to Lake Erie They

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[29] G K Stuntz, "On Some Recent Geological Changes in Northeastern Wisconsin," *Proc Am Assoc Adv Sci*, vol 18, 1870, pp 206–207

[30] A. C Lawson, "Sketch of the Coastal Topography of the North Side of Lake Superior with Special Reference to the Abandoned Strands of Lake Warren [Lakes Nipissing and Algonquin, W H H,] *20th Ann Rept. Geol and Nat Hist Surv Minn*, 1893, pp 181–289

[31] G. K Gilbert, "Recent Earth Movement in the Great Lakes Region," *18th Ann Rept U S Geol Surv*, 1898, pt 2, pp. 595–647.

[32] F E Wright, "Report on the Progress Made by the Porcupine Mountain Party during the Summer of 1903," *Rept Geol Surv. Mich for 1903* (1905), p 37

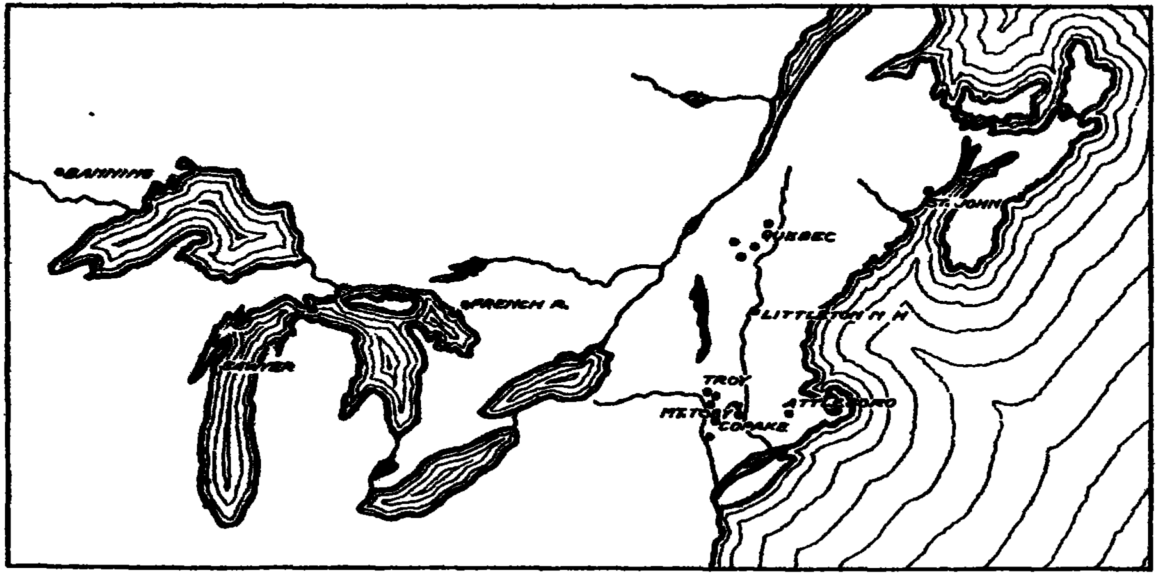

FIG 23 Sketch map to show where post-glacial faults have been observed within the glaciated region of North America Of those from the province of Quebec only a few have been entered

show that here also the tilt of the land is upward toward the north From the rate of flooding of the shores of Sandusky Bay Moseley has estimated that the rate of submergence on this shore is 2 14 feet per century[33]

Lake Michigan-Huron, for this is a single body of water, has its outlet at Port Huron far to the south and now to the southward of the hinge-line of uptilt Were this not the case flooding of the Chicago shore of Lake Michigan and of Bay City shore of Saginaw Bay would be going on

*Post-glacial faults* — Evidence is at hand that faults have been an accompaniment of the epeirogenic movements which have been going on within this region The continental glaciers which in the yesterday of geology covered the region, planed the rock surfaces to a fresh polished condition upon which any subsequent displacement, even though of small measure, must be revealed whenever diligently sought for No such search has been generally made, but already a considerable number of observations widely scattered through the region have been put on record (Fig 23)

Such post-glacial faults appear to have been first noticed by Mather[34] at Copake, N Y near the common corner of Massachusetts and Connecticut Similar faults have since been described by Matthew[35] from St John, New Brunswick, by Chalmers[36] from many localities in the province of Quebec, by C H Hitchcock[37] from Littleton, N H, by Woodworth[38] from many localities in eastern New York and Massachusetts, by Lawson[39] from Banning in Western Ontario, by Hobbs from Sawyer, Wisconsin,[40] and the French River in Central Ontario,[41] and by Loomis[42] from Mt Toby, Massachusetts While these faults are generally small individually they are numerous and they grow large in the aggregate

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[33] This is notwithstanding the fact that the present hinge-line of tilting now crosses the northeastern half of the lake. Gilbert's earlier estimate of the rate of uptilt (*18th Ann Rept U S Geol Surv*, 1898, pt 2, p 637), even as corrected by Lane (*Geol Surv Mich*, vol 7, 1900, pp 36–39), is in error and much too large, since he conceived the entire area about the lakes to be tilting like a plane without recognizing the positions and the migrations of the hinge-lines (*Mich Geol and Biol. Surv*, Pub 5, 1911, pp 40–41)

[34] W. W Mather, *Geology of New York, Report on First District*, 1843, pp 156–157

[35] G F Matthew, "Movements of the Earth's Crust at St John, N B. in Post-Glacial Times," *Bull Nat Hist. Soc. New Brunswick*, no 12, 1894, pp 34–42.

[36] R Chalmers, "Report on the Surface Geology and the Auriferous Deposits of South-Eastern Quebec," *Geol. Surv Can*, *Ann Rept*, vol. 10, 1897, pt. J, pp 10–12

The faults of eastern New York have been found chiefly along the lineament which follows the Hudson River and its continuation northward The lineaments of the northeastern United States in their relation to the recorded earthquakes of the district as the data have been assembled by De Montessus have already been put upon record[43]

## CONCLUSION

The earthquake of February 28, 1925, was felt throughout the glaciated area of North America and at relatively few places outside It was peculiarly an earthquake of this Laurentian area, and it is best explained as due to epeirogenic block movements as a result of continued uptilt of the area depressed during the periods of glaciation. The earthquake history of the region affords no warrant for the belief that the region of the northeastern United States is to remain immune from destructive earthquakes. Such visitations, it may be assumed, will be far less frequent than earthquakes which occur within the great girdles where mountain growth is proceeding lustily, but there is every reason to suppose that the future will bring to the Laurentian region earthquakes which are comparable in intensity with those of 1663 and 1811 So long as light shocks continue within the region, there is reason to believe that at least a partial relief from earth strain is being secured, and the date of the next destructive shocks is correspondingly removed farther into the future. Paradoxical as it may appear, the time for alarm will come whenever the region becomes abnormally quiescent

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[37] C H Hitchcock, "The Geology of Littleton," in *History of Littleton*, 1905, pp 28–29.

[38] J B Woodworth, "Post-Glacial Faults of Eastern New York," *Bull 107 N Y State Museum*, 1907, pp 4–28

[39] A C. Lawson, "On Some Post-Glacial Faults near Banning, Ontario," *Bull. Seismol Soc Am*, vol 1, pp 159–166

[40] W. H. Hobbs, "The Late Glacial and Post-Glacial Uplift of the Michigan Basin," *Mich Geol and Biol. Surv*, Pub 5, 1911, p 45

[41] W H Hobbs, "Post-Glacial Faulting in the French River District of Ontario," *Am. Journ Sci*, vol 1, 1921, pp 507–509

[42] F B Loomis, "Post-Glacial Faulting about Mt. Toby, Massachusetts," *Bull Geol Soc. Am*, vol 32, 1921, pp 75–80.

[43] *Beiträge zur Geophysik*, vol 8, 1907, pl 2

UNIVERSITY OF MICHIGAN
April, 1925

# HEMATITE INCLUSIONS IN THE LAKE SUPERIOR AMETHYST

### † EDWARD F HOLDEN

DURING the course of an investigation on the nature of the pigment of amethyst,[1] a number of specimens from the Thunder Bay district were examined This locality is on the northern shore of Lake Superior

The amethysts from Thunder Bay frequently contain abundant reddish-brown spots. They are quite small, with a diameter generally less than one millimeter The inclusions are of interest both because of their form and because of their relation to the color of amethyst They were identified as hematite, since

(1) They have a red streak, and color the powdered amethyst a pale brick-red

(2) Analyses showed the spotted amethyst to contain comparatively large amounts of iron One specimen contained 0 35 per cent $Fe_2O_3$, which was largely due to the inclusions, though a few hundredths of a per cent must have been contributed by the ferric compound found to be the pigment of amethyst.

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† The writer of this paper, Dr Edward F Holden, met his death by drowning on August 5, 1925, at North Deer Isle, Maine He was born on August 29, 1901, at Woonsocket, Rhode Island He had been a member of the staff of the Department of Mineralogy of the University of Michigan since 1921 and of the Michigan Academy of Science since 1922 He was particularly interested in the cause of color in minerals and his investigations on the color of rose quartz, amethyst and smoky quartz have appeared in recent issues of *The American Mineralogist* Dr Holden was also one of the assistant editors of *Chemical Abstracts* and an associate editor of *The American Mineralogist* His death removes from our membership one of the most promising of the younger scientists — EDITORS' NOTE

[1] Reported before the Section of Geology and Mineralogy under the title "The Pigments of Amethyst and Smoky Quartz," April 2, 1925 The present paper is a portion of the longer and more general paper then given

(3) The inclusions are entirely soluble in hydrochloric acid.

The hematite inclusions are distributed in definite planes parallel to and generally very near the surface of the crystals In form they are circular, having the appearance of the cross-section of an oolite They are not spherical, however, but are disk-shaped If a fragment containing some inclusions is tipped up, under the microscope, the hematite particles can be looked at edge on, and their thin, flat character is apparent. A microphotograph of a typical group of inclusions is given in Figure 24

FIG 24 Microphotograph of Hematite Inclusions in Lake Superior Amethyst

The specimens in which they occur have a pronounced lamellar structure, parallel to the rhombohedron faces It seems probable that iron-bearing waters were included in the spaces between the lamellae, and on gradually evaporating they left the inclusions in the form just decribed.

The investigation of a large number of amethyst specimens has shown that its pigment is very probably a compound of ferric iron The distribution of the hematite inclusions in the Thunder Bay amethyst confirms this hypothesis In these crystals the violet color was deepest for several millimeters below the thin layers of hematite inclusions, the rest of the crystals being white or colorless In most crystals there appears to be but one zone of hematite inclusions, but sometimes two or more layers are present. In a crystal with two zones of hematite particles the intervening layer of quartz was so dark a violet as to appear almost black The hematite inclusions are very close to the surface of most of the crystals These relations indicate that violet quartz began to be deposited when a sufficient concentration of iron was attained in the mineral solutions, the quartz previously formed being colorless. As the amount of iron increased, the color became darker, and finally the deposition of hematite took place There is, therefore, a correlation between the abundance of iron and the violet coloration

UNIVERSITY OF MICHIGAN

# GEOLOGY AS A FACTOR IN SOIL CLASSIFICATION

J O VEATCH

SOIL is an object of nature in which differences exist and wherever man is able to perceive differences, he makes comparisons and begins a classification although it may be unconsciously The classification may be crude, illogical, artificial when viewed in the light of later knowledge, but schemes change, undergo evolution and become more perfected as knowledge of the object to be classified accrues Ever since man became civilized and drew a great part of his sustenance from the cultivation of soils, he has made comparisons or has attempted to classify them

In the United States early comparisons or classifications have been purely local or provincial, never comprehensive or universal in their application Environmental or external factors, more often than intrinsic properties, other than perhaps a single peculiarity, have been made the basis of comparison and rarely were distinctions made between land and soil Pioneer settlers, farmers, agriculturists and naturalists made comparisons upon the basis of topography and drainage, natural vegetation, soil color, underlying rocks, agricultural use, and in various parts of the country we had upland and bottom land, hill land and level land, prairies and forest land, pine land and hardwood land, black lands and red lands, cotton land and tobacco land, granite soils, limestone soils, etc As the need for more exact comparisons and classifications became appreciated, workers in the sciences of chemistry, physics and geology felt called upon to apply some of their knowledge and laws to the study of the soil We began to accumulate more exact or scientific comparisons and knowledge in place of the utilitarian, spontaneous and more or less obvious comparisons. The chemist contributed essential knowledge concerning the soil, but as we all know, his analysis was utterly impracticable as a basis of soil classification. The physicist provided facts quite as fundamental in relation to plant growth as those of the chemist, but physics could give us no basis for a universal system of soil classification The agronomist viewed soils purely in relation to crop productivity and farming and, therefore, could evolve no comprehensive systematic scheme of classification

The geologist, however, was able to provide a scheme which promised to have a universal application and serve as a basis for the actual mapping of soils Soils were to be classified according to their geologic origin sedentary and transported, residual, alluvial, cumulose, etc., while a close correlation was assumed between the soil and kind of rock from which it was derived The geologic conception of soils has been pretty generally adopted and has exerted a strong influence in soil studies

The early system of classification initiated by Dr Milton Whitney and the U S Bureau of Soils about twenty-five years ago, was essentially geologic, since soil provinces were either geologic or physiographic, while origin and source of material were controlling factors in determining the series and types, in conjunction with texture, color and structure of the soil.

But now a new conception of soils, in their genetic and taxonomic relationships, is beginning to gain acceptance among soil scientists in this country. The two men who are chiefly credited with having evolved the new conception, or with greatly modifying old views, are K Glinka, the Russian pedologist, and Dr. C. F. Marbut of the U S. Bureau of Soils Glinka published a book in German in 1914, *Die Typen der Bodenbildung*, in which his scheme of universal soil classification is presented and his theories of soil formation are outlined in a comprehensive and masterly manner. Dr. Marbut was quick to appreciate the basic worth of Glinka's book, but without accepting all of the conclusions, and began to disseminate, in a quiet way, the Glinka conception of soil, which is in brief: Climate, not geology, is the primary or controlling basis of soil classification; the moisture, or drainage, and temperature conditions are the main controlling factors in soil development, the nature of the soil profile, the result of the action of chemical, physical and biotic agencies, differs in different climatic belts, and the age of the soil — the maturity or on the other hand incompleteness of the profile — is an important consideration

Dr Marbut [1] has defined the soil unit and named the criteria, or factors, which can be used in its differentiation He has established a principle which will have a far-reaching effect upon the work of the pedologist or scientist in soil classification. This principle is. The divisions and units of the soil classification must be differentiated on the basis of *intrinsic* characteristics of the soil itself. There is nothing illogical or radical in insisting upon the soundness of this point of view If one were to make a proposal to botanists that trees be classified upon the basis of the soil in which they grew, the proposal would be rightly treated as nonsense, the mineralogist bases his classification of minerals upon their own intrinsic chemical and physical peculiarities, not upon occurrence in a certain geologic formation or in a certain physiographic province. Then is it not logical since plants, animals, rocks and minerals and other objects of nature are classified on a natural basis, the basis of intrinsic peculiarities and properties, that soil also should be classified on this basis and not upon the basis of external and associated things, whether geology, climate or agriculture?

In the full acceptance of the foregoing viewpoints there may be a tendency at first to subordinate and ignore the geological factor too far. Geology, however, remains an important factor and it is the duty of the soil scientist, or more particularly the pedologist, to evaluate it in each particular region or locality that he studies. But, to state the matter rather bluntly, geologic origin and source of material are no longer to be regarded as the primary and controlling basis of the soil classification. Climate admittedly transcends geology in importance as a cause of differences between the larger orders of the soil classification To give a familiar illustration, the broad differences between the soils of the northern regions, the podsols, and those of the sub-humid treeless regions, the tschernosems, are a function of climate, the geologic source of material is entirely a subordinate factor In smaller subdivisions the moisture conditions under which the soil has developed, the age of the soil, and the degree to which the processes of *eluviation* and *illuviation*, leaching and concentration, have operated may be controlling factors, but here geology generally appears as a modifying factor

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[1] Marbut, C. F, "Contributions of Soil Surveys to Science," *Proceedings, 41st Annual Meeting, Society for the Promotion of Agricultural Science*, 1920, pp 116–142. Also Bull. III, pp 24–34, *Report, Second Annual Meeting, American Soil Survey Association*, Feb, 1922.

A close correlation between geology and soils, between a geologic map and a soil map, will depend upon whether the geologic divisions and the soil divisions are of the same order, even were there no other causes for a lack of unity In general no correlation between a geologic formation and a single soil type could be expected, because the two divisions are rarely of the same order And again it is patently futile to attempt to establish any significant relationships where a geologic formation or group of rocks has a distribution in two or more climatic divisions To give an extreme illustration, the soils from a Carboniferous limestone in Alabama and Georgia and one from a Carboniferous limestone on the arid plains of New Mexico would be quite dissimilar, even were the rocks identical in every respect Locally, a relation between texture and chemical and physical characteristics of a soil type may be close or on the other hand almost non-existent, accordingly as geologic subdivisions are made purely on a lithologic basis, or on the other hand, on the basis of age or fossil life forms, or in the case of glacial deposits on the basis of manner of deposition and topographic expression

It should be understood, however, that this relationship is not everywhere simple and that a mere statement of the kind of rock and source of material is not equivalent to a description of the soil. We know from extensive observation that the climax soil, the final product of the operation of soil-forming processes, may bear only a remote resemblance to the lithologic and physical aspect of the subjacent rock. This is particularly true under extremes of climate Even in a region like Michigan, where the surface formations are glacial deposits and the land surface is relatively youthful, the structural and other resemblance between horizons of the soil profile and the underlying geologic deposit may be almost entirely obliterated, as for example in certain types of the Fox and Waukesha where the B horizon may be highly compact, clayey and acid while the parent deposit is coarse, pervious, unconsolidated and calcareous Close consanguinity between the rock and the soil may exist, but it can be traced only by intricate microscopic, chemical and geologic study of both the soil and the rock, while the relationships must be worked out for each separate horizon of the soil profile, since in each there is a different expression of the relationship In one instance the relationship may be marked in texture, in another in color, in another in chemical nature Only the very broadest generalizations, exceedingly difficult to formulate, can be made for universal application We cannot even state that universally a 'parent' formation of sand will produce a soil uniformly sand in textural class throughout In general, relationships are purely local in value Extremely scant information is conveyed about the actual nature of the soil itself merely to state that it is a 'limestone' soil or a 'granite' soil, etc , unless the influence of the rock is interpreted in soil terms which is a task requiring laborious study and mental effort if it is to be done in more than a superficial manner If the object be a soil map, a more logical, a simpler and more direct method is to work out the soil classification on the basis of the soil itself When this is done, comparisons and relationships to rocks, vegetation, climate and agriculture may be made, and one may make whatever use of the relationships their worth may merit

Again a close parallelism between the distribution of soil types and geologic formation depends upon the uniformity of drainage conditions, since if the drainage conditions vary throughout the geological terrane, it is quite probable that there will be as many soil types as there are drainage types. In a region like peninsular Florida where climatic conditions have tended to make all the mature soils uniform lithologically, that is dominantly siliceous sand, regardless of the nature of the geologic formation underlying, the important surface soil differences are due almost entirely to the drainage or moisture conditions under which the soils have developed But even here, however, as elsewhere, the geologic substratum may be an important factor in the soil differentiation where it lies at a shallow depth and within reach of plant roots

It is seldom that a geologic map can be interpreted directly in terms of plant growth or seldom that it has a direct application to agriculture, its relation to soil must first be worked out and thence through the medium of soil we may state the relation to plant growth and to agriculture. A near equivalency of the surface part of a geologic formation, or deposit, and a soil may exist in the case of very recent alluvium, recent volcanic deposits, recent beach deposits, recent dunes, some peat deposits — land so new that soil-forming agencies have not had time to produce visible results Under such conditions the soil profile is immature and incomplete, and the pedologist simply describes the surface part of the deposit in soil terminology.

In connection with the discussion of the completeness and incompleteness of soil profiles, the postulation is here made that all soils are residual. Differences appear merely in the degree of alteration of the associated geologic formation This applies regardless of the geologic origin and age of the rock whether pre-Cambrian granite of the Piedmont plateau, Tertiary sand or marl of the Atlantic Coastal plain, the deposits of Wisconsin glaciation, or a recent peat deposit The sand dunes on the east side of Lake Michigan, which are geologically very recent, exhibit incipient soil profiles and in fact in places a marked alteration of the sand appears Again cumulose or peat deposits may be divided into groups, or organic soil types, on the basis of degree of surface alteration of the parent organic deposit, or stated in another way, upon the basis of the relative age of the soil and completeness or incompleteness of the soil profile One of the principal reasons why the classification of regolith given by

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[2] George P Merrill, *Rocks, Rock Weathering and Soils* (Macmillan Co, 1913), p 288

Merrill[2] fails when applied to soils is that all soils are in a strict sense residual.

The foregoing statements have not been made with a conscious purpose to belittle or to derogate the importance of geology in soil study. On the contrary I regard a knowledge of geology and physiography as a part of the essential equipment of the pedologist A knowledge of the geology and history of a land surface has a high value in working out academic relationships, facts of broad scientific interest, it constitutes a factor in the speculative study of soil, in deciphering the history of a soil, in tracing its evolution, in speculative studies upon the absolute age of a soil and the time required for the development of a profile under different geologic and climatic conditions, the causes for the alteration and degradation of soils; in distinguishing between acquired and inherited characteristics, in determining the causes for distribution of a soil type within the limits of a soil province, a detailed knowledge of the lithology of the geologic formation which has had an influence upon a soil, greatly facilitates theoretic explanation of some of the chemical and physical phenomena of horizons of the soil profile. In a strictly technical sense, the substratum constitutes a part of the complete soil profile, its C horizon, and, therefore, a consideration of its nature is important in the taxonomic study of the soil.

Some observations on the relationships of soil and geology with particular reference to Michigan may be given here A very excellent map of the surface formations of Michigan has been made by Leverett,[3] while recent soil surveys have been made of eighteen counties and in addition extensive reconnaissance studies of the soils, have been made during the past four years. When the geologic divisions and soil divisions are compared we find that in association with *moraines*, twelve soil series have been differentiated exclusive of mucks which may number three or four additional types, *clay till plains*, fourteen soils exclusive of mucks; *outwash plains*, nine soils, exclusive of mucks, *lake clay*, nine soils exclusive of mucks; *sandy lake beds*, fifteen soils exclusive of mucks, river deltas, four soils It is, therefore, evident that no consistent relation, over a large area, between the geologic division and the soil series or type exists The causes for this lack of close relationship are fundamental The mature soil and the geologic formation underlying are never entirely synonymous, because of alteration of the underlying rock by weathering and soil-forming agencies The accompanying Table illustrates some of the changes which have taken place in geologically recent glacial deposits in Michigan in their transformation of soil

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[3] Frank Leverett, "Surface Geology of Michigan," Pub 25, *Michigan Geological and Biological Survey*, 1917.

PARENT GLACIAL DEPOSIT AND SOIL

| Parent * | | Soil | | Parent † | | Soil | |
|---|---|---|---|---|---|---|---|
| | Clay percentage | $A_0$ $A_1$ horizon | Clay percentage | Lacustrine | CaO-MgO | $A_0$ $A_1$ horizon | CaO-MgO |
| Reddish till clay | 28 2 | $A_2$ horizon | 6 0 | Clay | 22 23 | $A_2$ horizon | 3 10 |
| | 28 2 | $A_3$ horizon | 11 7 | | 22 23 | $A_3$ horizon | 5 28 |
| | 28 2 | B horizon | 22 5 | | 22 23 | B horizon | 9 10 |
| | 28 2 | C horizon | 28 2 | | 22 23 | C horizon | 22 23 |

* Ogemaw Co , Kewaunee loam soil type mechanical analysis U S Bureau of soils

† Alcona County, Ontonagon silt loam analysis from Soil Profile Studies in Michigan" by M M McCool J O Veatch and C H Spurway in *Soil Sci* Vol XVI, No 2 Aug 1923

Again, equivalency does not exist, because in general the peculiarities of soil types which are inherited from the subjacent formation are related almost wholly to lithologic character rather than to origin, geologic age and manner of deposition If the geologist would further minutely subdivide the moraines and other divisions upon the basis of lithologic variations in the surface exposures, and after this is done were a still further subdivision made upon the basis of differences in drainage conditions, then the geologist's map and the soil map would doubtless reveal a closer parallelism, provided recognition were given to climatic differences Our soil studies in Michigan have strongly suggested that the generalized profiles in the northern part of the State are sufficiently different from those in the southern part to warrant the establishment of two broad soil divisions or provincial orders, and that those differences are climatic in origin True podsols occur in the northern part of the State, while in the southern part of the southern peninsula brown forest soils and degraded podsols are present

In a glaciated region like Michigan, where the land surface is *youthful*, where there has been but little or no alteration of the constructional topographic forms, inherited soil characteristics are more closely associated with the subjacent formation than in an old non-glaciated eroded region A geologic map therefore, such as that made by Leverett, has a great value in pedologic investigations It is hardly to be expected that an outwash plain or a moraine or any of the other divisions of the same order would have the same meaning in soil terms throughout the whole State, because of the variations in lithologic character and in drainage However, when local interpretations are made, soil group-relationships may be established, particularly textural groups, and hence, the geologic map may be very useful in reconnaissance soil-mapping and in working out problems of soil origin and geographic distribution

If detailed petrologic descriptions of the drift were available, a quantitative estimate of the different kinds of rock in the moraines, outwash plains and till plains in different localities, together with chemical and mechanical analyses of the unaltered drift, the value of geology as a factor in the soil classification in the State would be greatly increased Additional knowledge would be available which would be an important aid in our efforts to explain many of the chemical and physical phenomena of the soil profile But, however detailed a geologic map may be, however minute the description of the rock or formation, the map cannot be regarded as the equivalent of the soil map, because drainage or moisture conditions under which the soil has developed, the relative age of the soil, the number and arrangement of soil horizons, their thickness, their color, texture, structure, their colloidal content, their reaction, their organic matter, their moisture relationships, their relative amounts of plant food elements are not a part of the geologist's criteria of differentiation The consideration of these things or soil taxonomy and profile analysis in conjunction with the origin, evolution and geographic distribution of soils constitutes a new science — pedology.

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# THE PAPACY AND HISPANIC INTERSTATE RELATIONS, 1195–1212

BENJAMIN WEBB WHEELER

FROM the eleventh to the thirteenth century the evolution of the map of Spain shows, in general, a tendency for the states whose rulers were of Christian faith to occupy an increasingly larger area of the Iberian Peninsula, while the territory ruled by Moslems grows correspondingly smaller Progress in this direction was, of course, by no means steady or continuous, but the territory controlled by the Christian states was vastly greater in 1200 than it had been in 1000 Although the decentralizing or disintegrating factors which at times made the Moslem states an easier prey than Christian neighbors, will not be discussed here, it is well to be reminded that the growth of the Christian powers was not the result of a crusade; that is, if by a crusade we mean a concerted effort in which elements of otherwise divergent interests were united under the symbol of the Christian faith Out of the unconquered remnant of the old Gothic kingdom, several small dynasties had arisen Each was ambitious to increase its inheritance and was ready to do this at the expense of its weakest neighbor, whether Moslem or Christian

At the end of the twelfth century the Christian states were five in number, Aragon, Navarre, Castile, Leon and Portugal Castile, Leon and Portugal were all ruled by kings descended from Alfonso VI, king of Leon, Galicia and Castile from 1083 to 1109 A bitter dynastic rivalry existed between Portugal and Leon, for the former had originally been established as a fief of the latter,[1] and had won the status of an independant kingdom through war and through diplomatic enlistment of papal support The king of Leon was also a natural rival of his cousin, the king of Castile, whose vassal he nominally was In fact there existed a general suspicion of the king of Castile, for it was apparently feared that the pretensions of Alfonso VII to peninsular empire might be renewed.

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[1] More strictly as a fief of Galicia, which remained united with Leon from the time of Alfonso VII of Castile, Leon and Galicia (1126–1157)

As a result the late eighties and early nineties of the twelfth century had seen a general alliance among the Christian states against Castile An interdynastic marriage temporarily lulled even the bitter strife between Leon and Portugal,[2] and in 1195 Alfonso VIII of Castile (1158–1214) found himself isolated before the Moslem armies by whom he was bitterly defeated at the tragic battle of Alarcos (July 19)

Although, as has been pointed out, the spirit of the crusade was not the leading factor in the statecraft of the Spanish princes, it is not to be left out of account entirely It afforded added zest to war against the Moslems and often served, together with the hope of plunder or the promise of a fief, to bring from Northern Europe the help of some adventurous warrior

It is said that the news of the disaster at Alarcos stunned Europe To estimate the effect of an event on public opinion is more difficult for the twelfth than for the twentieth century, but in the years immediately following the disaster there is evidence of a much more vigorous effort on the part of the reigning pope to unify the Christian princes against Islam

On the 29th of March, 1196, Celestine III addressed a note to Sancho VIII, the duke of Navarre The divine wrath of God has permitted the infidel to win a victory over Christendom and there is need for concerted action among the Christian powers. Celestine has learned that Sancho has entered a compact with the Moslems, agreeing in return for an annual payment to refuse aid to the Christian kings "at this critical time"

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[2] For an account of the circumstances surrounding this marriage and the questions of chronology involved, see Herculano, *Historia de Portugal*, 2 67, and n 2 Schirrmacher, *Geschichte von Spanien*, 4 244 and 249 It appears that the marriage was solemnized in the spring of 1191 and soon thereafter declared illegal on grounds of consanguinity

(*in hujus necessitatis articulo*). He urges him to desert this alliance and join with the "kings of the Spains" (*reges Ispaniarum*), and especially those of Castile and Aragon, in an alliance on terms which he proceeds to specify. The pact is to be sponsored by ecclesiastical and lay dignitaries, headed by Gregory, cardinal deacon of Sant' Angelo, Celestine's legate. These are to see to it that an equitable division is made of any land captured from the Moslems. The duke of Navarre is to be guaranteed free access to the Moslem frontiers for purposes of carrying war against them and also to whatever conquered territory may be allotted to him.[3] Corresponding letters went forward to Cardinal Gregory,[4] to the kings of Aragon and Castile[5] and to three Spanish bishops.[6]

To clinch the adherence of Sancho of Navarre to the cause of Christendom, he is dignified by the pope with the title of 'king' and is so addressed in a letter of April 22, 1196, wherein he is reminded that the added dignity of his new title entails upon him a heavier obligation.[7]

Of all the Iberian states Navarre alone was cut off by her neighbors from contact with the Moslems. Pinched between the relatively powerful states of Castile and Aragon, it was natural that she should find an ally in the more remote Moslem power.

In her policy of alliance with Islam she had a companion among her fellow-Christians. With a relatively narrow frontier against the infidel and a long neck of territory extending between an only temporarily pacified Portugal and a never-to-be-trusted Castile, the king of Leon had sought to seize the opportunity of his cousin's clash with the Moslems to lay hands on Castilian territory.[8]

The marriage which in 1191 had united the houses of Leon and Portugal had promptly been ordered dissolved by Celestine III on grounds of consanguinity  Failing to heed the divorce order, the kings were excommunicated and their lands subjected to an interdict [9]  The separation finally took place in 1195 or early in 1196 [10]  In February of 1196 Sancho of Portugal was visited by the king of Aragon who was apparently acting as intermediary for the formation of a new alliance [11]  In any case the natural course for King Sancho to follow was to renew his long-standing feud with the king of Leon  In so doing he ranged himself beside the king of Castile, who was still at war with Leon  The enemies of Leon were further strengthened by a bull issued on October 31, 1196, preaching the crusade against the king of Leon and the renegade Castilian, Pedro Fernandez de Castro, who was believed to have been largely responsible for the king's alliance with Moslems  To those bearing arms against them the same indulgences are offered as to those fighting the infidel [12]  In April, 1197, the king of Portugal received further encouragement from the pope, who authorized him to keep whatever he could take from the outlawed Alfonso IX of Leon.[13]

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[3] Bull of Celestine III, published by Fidel Fita, "Bulas Historicas de Navarra," *Boletin de la Real Academia de la Historia*, 26 (1895) 418–420.

[4] *Ibid.*, pp. 420–423. (This letter is dated May 28, the others are of March 29.)

[5] Published by Fidel Fita, "Bulas Ineditas," *ibid.*, 27 (1895). 225–227.

[6] *Ibid.*, pp. 227–229.

[7] *Ibid.*, pp. 229–230.

[8] Rodrigo de Toledo, *De Rebus Hisp.*, quoted by Fita, "Bulas Historicas de Navarra," *op. cit.*, 26: 417, n. 2.

The effort of Celestine III to unify the Christian kings of Spain against the Moslem power had enjoyed only a limited success  Navarre remained at war with Castile and Aragon and the legate Gregory felt obliged to place an interdict upon her [14]  Portugal, however, became the ally of Castile in 1196 and Pedro II of Aragon, who came to the throne in April of that year was and remained until his death the staunch ally of Alfonso VIII.

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[9] *Inn III Epist*, Lib II No. 75, ed Baluze, reprinted in Migne, *Patrol Lat*, Vol 214 cols 610–615

[10] Herculano, *op. cit*, 2 75, and n 4  It is argued (n 4) that the earlier date is more plausible since the king of Aragon, who came to Coimbra in February of 1196 to make overtures for a new alliance, must have known in advance of the estrangement  It is possible, on the other hand, that the separation was the result, rather than the cause, of the Portuguese king's interest in the new alliance

[11] Herculano, *loc. cit*, Schirrmacher, *op. cit.*, 4 257, and n 2.  Both cite the *Coimbra Chronicle*

[12] Bull of Celestine III, quoted by Fita, "Bulas Historicas de Navarra, *op cit*, 26 423–424, also in 11 (1887) 457

[13] Bull of Celestine III in Brandão, *Monarchia Lusitanea*, XII, c

[14] *Inn III Epist.*, Lib I, No 92, Migne, *op. cit*, Vol 214, col. 80 A.

Thus the alliance against Castile had dissolved and of the five Christian states only two remained hostile to the victim of Alarcos. By the beginning of 1198 one of these two had entered the fold, for a marriage had been effected between Berenguela, daughter of Alfonso VIII of Castile, and King Alfonso IX of Leon.

This marriage, however, was not to serve as a permanent guarantee of peace between the two kingdoms. Shortly after its contraction Celestine was succeeded by Innocent III Surely this pope, with his ambition to increase the limits of Christendom, must have been ambitious for a triumph of Christian arms in Spain But first of all his interest was in the establishment of ecclesiastical authority and the enforcement of church law. His instructions to his legate, Cardinal Rainer, April 16, 1198, portray the situation The function of the mission is virtually described in the preamble as the "reëstablishment of peace among the princes and the dissolution of iniquitous unions" The latter, that is the dissolution of the consanguineous marriage between Berenguela and Alfonso of Leon, was the legate's first duty. He is also charged with seeing that the kings make an effective peace with one another and especially with the king of Portugal. In the third place he is to investigate the interdict placed upon the kingdom of Navarre on account of breaking the truce with Castile.[15] In annulling the marriage alliance Innocent met with stubborn resistance[16] Not until 1204 did Berenguela leave her husband.[17] That did not end the trouble, however Hostilities between Leon and Castile were renewed because of a dispute over certain castles with which the king of Leon had endowed his bride These she and her father undertook to retain Innocent ruled that they should be returned, since the marriage was properly no marriage at all [18] A peace settlement was finally effected in 1206 according to which the castles were to be delivered to the joint offspring of the marriage [19] This settlement, however, was distinctly in opposition to Innocent's wishes, for it involved the recognition of Ferdinand who, according to his interpretation, was born out of wedlock and therefore not entitled to any inheritance [20]

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[15] *Ibid*, 79–80.

[16] *Ibid.*, Lib II, No 75, Migne, *op cit.*, Vol. 214, cols 610–615, May 25, 1199 The case is reviewed in full The king of Leon having failed to repudiate his wife was excommunicated and an interdict laid upon his kingdom The kings of both Leon and Castile had sent ambassadors to Rome whose most cogent argument in favor of a relaxation of the interdict was that it hindered the cause of the crusade Innocent did relax the extreme severity of the interdict, but refused to remove it

[17] *Ibid.*; Lib. VII, No. 67; Migne, *op cit*, Vol 215, col 345, May 22, 1204 The archbishop of Toledo and certain bishops are instructed to absolve Berenguela who has now left Alfonso IX The king of Leon was similarly absolved, June 19, 1204 (*Ibid*, Lib. VII, No. 94, Migne, *op cit*, Vol 215, col 376).

In every state of Spain Innocent effected a triumph of ecclesiastical authority, but in the larger affairs of the Peninsula, the preparation for the triumphant national effort at Las Navas, his was a guided rather than a guiding hand His greatest service, perhaps was performed in 1198 when he was able to restrain Castile from joining Leon in the war against Portugal, which continued until 1200[21]

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[18] *Ibid*, Lib II, No 75, and also Lib VII, No 93, Migne, *op cit*, Vol 215, cols 373-376, June 20, 1204 The disputed castles had been granted by the king of Leon to his bride with the proviso that, should he at any time repudiate her, she should retain them This accounts for Alfonso IX's unwillingness to repudiate his wife and Alfonso VIII's unwillingness to take her back on any other condition After the separation Alfonso VIII had responded to Innocent's order to return the castles with the subterfuge that they were occupied by his daughter, not by him Innocent orders the princess to deliver the castles to Leon or turn them over, in trust, to certain Spanish bishops until the matter can be settled by arbitration

[19] Treaty of peace between the kings of Leon and Castile (Peace of Cabreros) in *España Sagrada*, 36 CXXXII The castles are granted to Ferdinand, son of Alfonso IX and Berenguela It is specifically stated that they remain a part of the kingdom of Leon and that their lords owe allegiance to her king This peace was confirmed in 1207 by another agreement (*ibid.*, p CXLIV) in which the king of Leon assigns certain castles and an annual money payment to his former wife After her death the castles are to revert to the status described in the peace of 1206 The recognition of Ferdinand was in accord with an agreement entered upon by the two kings some years previously and promptly denounced by Innocent III, *Ep*, Lib VI, No 80, Migne, *op cit*, Vol. 215, col 83 A, June 5, 1203. War broke out again between Castile and Leon as is shown by a third reaffirmation of the peace of Cabreros (*España Sagrada*, 36 CXLVII) Further grants are made to Berenguela on the same terms as in 1207 Certain castles which violate the boundary are to be destroyed The treaty is to be submitted to the pope for ecclesiastical sanction

[20] *Inn III Epist*, Lib II, No 75, Migne, *op cit.*, Vol. 214, col. 614 C, and also as cited in note 19.

The situation remained very much that which Celestine III had left After the rupture of the marriage bond with Castile, the king of Leon once more leaned toward the Moslem alliance King Sancho VIII of Navarre, too, became effectively estranged from the Christian princes After Innocent III, again on grounds of consanguinity, had refused to let him marry the sister of Pedro of Aragon (an alliance forced upon him as an alternative to the dismembernment of his kingdom by Castile and Aragon),[22] he sought refuge with the calif and remained for some two years in Africa, while the allies took heavy toll of his tiny kingdom[23]

As time passed and the burdens of office increased, whatever ambitions toward the organization of a Spanish crusade Innocent may, in his earlier days, have felt, became more remote In 1204 the king of Aragon, who, even at this time may have been interested in an eventual conquest of the Balearic islands, had urged upon the pope the sending of a legate to organize a crusade among the Spanish kings But Innocent had learned by his own bitter experience and that of his predecessor that he could not make the Spanish kings of one mind or of one heart, and the sending of the legate was indefinitely postponed[24] Again in 1209, with the preaching of the Albigensian crusade, the center of Innocent's interest moved to Southern France A letter was dispatched to the kings of Aragon and Castile, urging their participation and arguing in favor of deserting, for a time, the crusade against the Moslem in favor of that against the northern infidel[25]

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[21] *Op cit*, Lib I, No 249, Migne, *op cit*, Vol 214, col 214; June 6, 1198 Castile and Leon were then at peace because of the recently contracted marriage alliance Castile was evidently tempted to join Leon in the war against Portugal. The legate Rainer was charged with the maintenance of peace between the kings of Leon and Portugal. The two monarchs had sworn to a treaty of peace but a short time previously (certainly not before the separation of the Portuguese Infanta from the king of Leon)

[22] *Op cit.*, Lib I, No 556; Migne, *op cit*, Vol 214, cols 509–510, Feb. 11, 1199

[23] Lafuente, *Historia general de España*, 5· 178–180, Schirrmacher, *op cit*, 4 266–269. Ballasteros y Beretta, *Historia de España*, 2 376

[24] *Inn III Epist.*, Lib. VI, No. 235; Migne, *op cit*, Vol 215, cols. 265–266

Notwithstanding discouragement the spirit of revenge was still alive in Spain Both Celestine and Innocent had recognized in Castile, whose monarch smarted from the disgrace at Alarcos and whose territories formed a bold salient into the dominions of Islam, the destined organizer of victory. During the years of controversy over the marriage of Berenguela Innocent had displayed the greatest forbearance toward Alfonso of Castile, Celestine had made Castile with Aragon (the state second in concern for the crushing of the Moslem power) the nucleus of his proposed Christian alliance

Only once does Innocent become vindictive toward Alfonso VIII. He has apparently discovered that the king of Castile had secretly engaged in negotiations with the king of Leon, involving the recognition of Ferdinand as heir Alfonso VIII is accused of having ensnared Alfonso IX, playing upon his simplicity and forcing him into a position where he could not, without great loss to himself, repudiate the Castilian Infanta Castilian counselors are said to have been forced upon him and most of the strongest border fortresses occupied by Castilian troops in the name of the Infanta. Alfonso VIII excused himself from vacating the occupied castles on the ground that it was his daughter and not he who was holding them[26] But these sins are soon forgiven and subsequent letters are again courteous and considerate.

As it became evident that concerted action could not be secured, Alfonso VIII determined to force the hand of Christendom. His eldest son was to win his spurs in battle with the infidel. Innocent could not refuse coldly the appeal of the young prince but satisfied himself in December of 1210, with a somewhat perfunctory letter to the Spanish bishops instructing them to urge upon their monarchs the support of the Castilian enterprise, so far as they had not bound themselves to the Moslems under a truce[27]

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[25] *Inn III Ep*, Lib XII, No 125; Migne, *op cit*, Vol. 216, col 154

[26] *Ibid*, Lib VI, No 80, Migne, *op cit*, Vol 215, col 82, June 13, 1203.

On February 22, 1211, the pope was persuaded to take a somewhat more definite stand. The Spanish bishops are instructed to curb with ecclesiastical censure any king who, having engaged in a truce or treaty of peace with King Alfonso or his son, ventures to violate it while the Castilians are carrying war against the Moslems[28]

As the cause of Christendom became more deeply involved in the Moslem war and Innocent became persuaded that the infidel sought "not only the destruction of the Spains but even threatened to vent his fury against other Christian lands," the petitions of the Castilians were further answered with the promise (February 4, 1212) of a recruiting campaign in France and Provence with the inducement of plenary indulgence for all participants But the letter concludes with the admonition that the world is all upset and in evil times, and the advice to take the first opportunity for a respectable truce and await a more favorable time for a conclusive war[29]

Not until after certain successes by the Moslems and the dispatch of another embassy to Rome did Innocent extend to the crusade the full strength of his support On April 4, 1212, a bull addressed to the archbishops of Compostela and Toledo, ordering the excommunication of the king of Leon "concerning whom specific mention is made" or any other Spanish king presuming to enter an agreement with the Moslems against the Christians[30]

Innocent had been cautious in his assumption of leadership. At no point had he run the risk of a step he might have to retract or a threat he could not expect to carry through

On the 16th of July was won the victory of Las Navas de Tolosa. As his allies in the great struggle Alfonso had the king of Aragon, the king of Navarre who after wavering until the eleventh hour was at last persuaded to cast his lot with the

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[27] *Inn III Ep.*, Lib XIII, No 183, Migne, *op cit*, Vol 216, col 353

[28] *Ibid.*, Lib. XIV, Nos 3-5, Migne, *op cit.*, Vol 216, cols 379-381

[29] *Ibid*, No. 154; Migne, *op. cit.*, Vol. 216, col 513

[30] *Ibid.*, Lib. XV, No. 15; Migne, *op. cit.*, Vol. 216, col. 553.

Christians, and the king of Portugal The king of Portugal was unable to be present himself because of disorder at home He was represented, however, by a contingent of knights The ultramontanes, who had come in response to the preaching of the crusade in France and Provence, had left the ranks on finding that the heat was great and the hope of plunder small On Alfonso VIII and on the kingdom of Castile devolved the furnishing of the largest contingent and the financing of the whole campaign[31]

In this first great successful crusade of the Spanish princes the head of the church had played a somewhat doubtful part From 1195 to 1198 Celestine III had made a magnificent effort to secure the cooperation of the Christian princes He had helped to form a triple alliance between Castile, Portugal and Aragon, but had succeeded only in emphasizing the cleavage which set apart the kings of Leon and Navarre His successor, Innocent III, had opened his career with ambitions to control the interrelations of the Hispanic states, but as time went on the independent spirit of the princes and the other burdens of his office led him to be content with the enforcement of ecclesiastical authority in lesser things, such as marriage laws and questions of clerical privilege[32] Perhaps it was his greater wisdom which prompted him to let the crusade lead him instead of attempting to force it as Celestine had done

His stamp of approval on the enterprise of the Castilian king was of undoubted help in securing participation almost peninsula-wide[33] Only the king of Leon remained true to his anti-Castilian and pro-Moslem tendencies

Alfonso VIII laid his victory in all humility at the feet of

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[31] Alfonso's report to Innocent III, concerning the campaign of Las Navas, *Inn III Ep*, Lib XV, No. 182, Migne, *op cit*, Vol 216, cols 699-703

[32] For instances of his repeated humiliation of the Hispanic kings, see Luchaire, *Innocent III*, *Les Royautés Vassales*, pp 1-57 *passim*

[33] *Ibid.*, pp. 25-26 Innocent, as executor of the will of Sancho I of Portugal (d 1212), relaxed his severity toward the new king, Alfonso II Apparently the change in policy was in the interest of the crusade (Portugal, however, was more important as a buffer against the hostile king of Leon than as a participant at Las Navas.)

Innocent[34] It was accepted by church and people as a victory of Christendom[35] In fact it was less and it was more The king of the great central state of the Iberian Peninsula had successfully led Spanish arms in an enterprise of his own making It was a great national triumph.

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[34] Alfonso's report as cited in note 31, especially cols 702 B and 703 A

[35] *Inn III Ep*, Lib XV, No 183, Migne, *op cit*, Vol 216, cols 703–704

# CRÈVECOEUR AND THOREAU

### J B MOORE

THERE is no strictly lineal relation between Crèvecoeur and Thoreau They both wrote in an eloquent strain about nature — that is, what we call external nature This is not the first time that their names have been brought together, a reader knowing Thoreau's *Walden* and Crèvecoeur's *Letters from an American Farmer* could hardly fail to weigh them against each other In the introduction to a recent edition of the *Letters from an American Farmer*, Warren Barton Blake says of Crèvecoeur· "We owe some concessions to the author of so charming a book, to the eighteenth-century Thoreau His life is certainly more interesting than the real Thoreau's "[1]

Crèvecoeur was 'eighteenth-century' but he was in no inherent sense a Thoreau, Thoreau being, as those familiar with him are aware, such a sharply unique person in most respects that to call anyone else 'a Thoreau' is paradoxical. But even in a looser sense of Thoreau as an exemplar of the early nineteenth-century attitude toward nature — even here, Thoreau is equally antipathetic to Crèvecoeur as an exemplar of the middle eighteenth-century attitude toward nature The surface resemblance between the two men (sufficiently remarkable) has led Warren Barton Blake into a thoroughly false analogy or implication. It would, nevertheless, be difficult to isolate an eighteenth-century lover of nature and a nineteenth-century lover of nature, in each case more clearly representative and, together, more opposed in feeling.

In declaring that Crèvecoeur's life is more interesting than Thoreau's, W. B Blake has again betrayed his own inexactitude or lack of information Is the life Thoreau chronicles in *A Week on the Concord and Merrimac Rivers* what one can safely venture to call less than the most spirit-stirring? Or is the book of trips *The Maine Woods* anything less than stirring even to one who finds outer excitement more rewarding than inner excitement? Or, better still, is there an hour of dullness in the life at *Walden?* W B Blake speaks with assurance of the life of Crèvecoeur, for which we have to depend partly on a single biography compiled by Crèvecoeur's great-grandson [2] (a book which seems to inspire to the full such doubts as are almost always incident to biographies of 'the great' by their own descendants), partly on Crèvecoeur's semi-autobiographical books and not a few miscellaneous letters, usually of an official sort Thoreau's life is particularly subject to interpretations, perhaps, but the occurrences are all undoubted and not manipulated by grand-filial piety Crèvecoeur's life is one of varied adventure, wide travel, many employments He appears to have been born in France, at the town of Caen, Normandy, in 1735 (And without repetition of the word 'appears,' it is necessary to pronounce it mentally at every turn in the account of his life, for Crèvecoeur himself had a fashion of juggling with dates and events of his career ) He received considerable instruction at the local Jesuit College as his later surveying and map-making attest About 1753–1754, he came to America, where he was naturalized in the province of New York, December, 1765, beyond doubt [3] What happened to him from 1754 to 1765 is one of those dark matters upon which more useless ingenuity has been and is like to be (for lack of evidence) expended than upon any vital question of his writings or undertakings One theory is that he was a certain recorded Crèvecoeur who campaigned under Montcalm against the English [4] The other theory is that — during the dark years — he was agent for a Philadelphia business-man. "This business seems to have involved a good deal of journeying about on Crèvecoeur's part, it appears probable that he was engaged in trading with the Indians during some of this time at least."[5]

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[1] *Letters from an American Farmer* (New York, 1913), Introduction, p viii

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[2] *St Jean de Crèvecoeur, sa Vie et ses Ouvrages* (Paris, 1883), by Robert de Crèvecoeur

[3] *St Jean de Crèvecoeur* (New York, 1916), by Julia Post Mitchell, Appendix, pp 307–309 The naturalization act is here quoted in full

[4] This is the theory promulgated by Crèvecoeur's great-grandson in the biography of 1883

Whichever theory prevails, the thing to remember is that, for nearly ten years, Crèvecoeur was travelling pretty widely in the New England provinces, and in the Central Provinces of Pennsylvania, New York, and New Jersey, and not improbably still farther afield or 'aforest' There is little in his later accounts of America that he might not perfectly well have observed or experienced in this protracted period of mystery

After his naturalization in 1765 came what may be definitely named Crèvecoeur's farming days At the time of the publication of his first book, *Letters from an American Farmer*, at London, in 1782, there was one Englishman (and probably he spoke for others beside himself) who doubted the genuineness of the 'letters,' the 'American,' and the 'farmer' This Englishman, Samuel Ayscough, issued a virulent little pamphlet in London, the next year — "Remarks on *Letters from an American Farmer*, or Detection of the Errors of Mr J Hector St John, pointing out the pernicious tendency of these letters to Great Britain" The author is alarmed by the alluring pictures in Crèvecoeur's book, for it will presumably swell the already increasing number of emigrants from England to the rebel colonies, and he seems to be honestly convinced — as a hard-headed Englishman is likely to be to this day! — of the spuriousness of the pictures The abundant sentiment and the literary artistry of the Farmer's Letters have never quite convinced not only Englishmen but also Americans Crèvecoeur was every inch a Frenchman in sentiment and in art Even such standard scholars in the area of American literature that includes Crèvecoeur's writings as W B. Cairns (to represent the traditional scholar) and F. L Pattee (to represent the independent and progressive scholar) stand together in slighting Crèvecoeur They omit him from their anthologies, they give him summary treatment in their histories This can hardly be comprehended except upon the supposition that the 'American Farmer' is not to the taste of later Americans

[5] *St Jean de Crèvecoeur*, pp. 11, 12 ("A Question of Identity").

He is allowed to be 'charming' or 'highly-colored' and dismissed in a few lines or a paragraph.[6] The answer to Samuel Ayscough and the rest of the Anglo-Saxon depreciators is not equivocal Crèvecoeur *was* an American farmer for the better part of the twenty years[7] His first farming on his own land was in Orange County, New York In 1769, according to the official record, he purchased a farm of his own, incited thereto, no doubt, by his marriage not many weeks earlier in the same year to Mehitable Tippet of Yonkers, New York[8] Crèvecoeur's domestic days and his farming days came at the same period and each lent a glow to the other, at least in retrospect His children were three, a daughter, America-Frances, born in 1770, a son, Alexandre, in 1772, another son, Louis, in 1774 These children were extremely dear to their father and lend, perhaps, as brilliant a tinge to his wilderness farming as the contact with the land itself

He cleared his land, though often reluctant to fell the trees, he drained his swamp, and made of it a fertile tract, and there is no reason to believe that he would not have remained a successful 'American Farmer' to the end of his days but for the American Revolution

He lived in the wilderness where there was no escape in case of the hostility of the Indians who were beginning early in the Revolutionary period to make descents upon isolated farms and villages. At any rate, if we may believe his own account of his emotions as given in the twelfth and last 'Letter' of the original edition of 1782, the letter entitled "Distress of a Frontier Man," Crèvecoeur suffered nothing short of panic at the approach of the war with England Naturally this attitude is not mentioned in his later writings, for presently (as one of the chief authorities upon America) he was made French consul to New York, New Jersey, and Connecticut, a position from which he certainly encouraged the notion that he had been sympathetic with the American patriots. As a matter of fact, unable to throw himself strongly upon either side of the conflict, in an altogether un-affected fright at the rumor of Indian raids, St. John determined to flee to France. The patriots who learned his intention, fearing that he might give information to the enemy, made great difficulty for him. He finally arrived within the British lines in New York, having left his wife, his daughter, and his youngest son, and he was accompanied only by his son Alexandre The British treated him more severely than the patriots. He was imprisoned in New York, because of vague accusations and suspicions,[9] and even after his release suffered more or less permanent injury from poverty and exposure during that winter of 1779 and 1780. Ultimately, the father and son were allowed to ship for England, where they spent some time, and where (in London in 1781) the 'American Farmer' found a publisher to purchase his manuscript 'Letters' He reached France that same year So ends the 'American Farmer' His *Letters* were published in London,[10] the next year From this time we have St. John the cosmopolitan, the bilinguist, the man of affairs in the typical eighteenth-century sense To be sure, the experiences as an American wanderer from 1754 to 1765 and the experiences as frontier farmer and at the same time husband and father of a family on his own farm from 1765 to 1778, these experiences were what he built his books upon, what he built his consulship upon, what he built his reputation upon, for the years from 1782 till his death in 1813. The Crèvecoeur whom we hear in *Letters from an American Farmer*, as far as his reflections upon nature and simple living go, is the American Rousseau not the American Thoreau But the ensuing period of his life affords ground for denominating him a kind of French Franklin Till 1781, Crèvecoeur is as thoroughly American as the majority of persons dwelling in America at that time After 1781, he pretty distinctly belongs to France. But always he is a curious compound of a second-rate Rousseau and a second-rate Franklin: on both sides the very antithesis to Thoreau.

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[6] Cf W B Cairns, *American Literature* (New York, 1912), p. 148.

[7] Julia Post Mitchell, *St. Jean de Crèvecoeur*, p 29.

[8] *Ibid.*, p. 36.

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[9] Julia Post Mitchell, *St Jean de Crèvecoeur*, p. 53.

[10] J Hector St. John, *Letters from an American Farmer, describing certain provincial situations, manners, and customs, not generally known, and conveying some idea of the late and present interior circumstances of the British colonies in North America*, London, 1882.

The rather destitute Crèvecoeur, who with much anguish reached France in 1781, remained there until 1783, the year of his appointment as consul to New York, New Jersey, and Connecticut During his French residence, Crèvecoeur scored a double success his book was published with such a reception in both England and Ireland, in 1782, that second editions were brought out the following year, and that Crèvecoeur felt encouraged to translate and expand the book for publication in Paris in 1784, and, simultaniously, he made an impression at Versailles by a "detailed report of conditions in the colonies relative to their geography, agriculture, industries, etc[11] This report won him his appointment as consul in 1783 Perhaps a third success should also be attributed to Crèvecoeur, at this time — his success in winning the interest and assistance of powerful members of French society Such friends as the Maréchal de Castries, the Duke de la Rochefoucauld, the Princess de Beauvau, and Madame d'Houdetot,[12] found Crèvecoeur so interesting that they gave ear,[13] and then support, to several of his cherished projects, for, like Franklin, he was fertile in plans to benefit the public or the nation in these latter years of the French period of his life Lafayette, Franklin, and Jefferson are the most famous of Crèvecoeur's correspondents though they are far from being the most intimate. It is significant that the two most tirelessly versatile and the two most Gallicized of the great Americans of the Revolution should have been Crèvecoeur's correspondents He wrote on two or three occasions, at least, to Washington, but the notes are purely official or formal and have no such interest as his letters to Jefferson and Franklin What acquaintance Crèvecoeur achieved with the two great Americans came through the recommendation of potent French patrons or patronesses

Crèvecoeur proceeded to New York as consul in 1783, not, however, before he had been the chief instrument in realizing one of the most precious projects of his life, a packet-line between

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[11] Julia Post Mitchell, *St Jean de Crèvecoeur*, p 79

[12] Cf. *Letters from an American Farmer* (edited by Warren Barton Blake, New York, 1913), p 248, Note X

[13] *Ibid*, p 242, Note IX.

France and America. As consul, he made it his concern to promote an exchange of seeds, plants, trees, and an exchange of methods in agriculture and horticulture, between France and America. Here is a characteristic inquiry culled from a letter Crèvecoeur wrote to Jefferson in 1784:

> It has been said in France that in some of the remotest settlements of Virginia or Carolina, Brandy has been distilled from Potatoes. That this Root Contains a Spirit as strong as that which is obtained from grain is beyond a Doubt, but the method of bringing it, in a State of Fermentation, is What Puzzles the Learned Chymists, Spite of the Many Tryals they have Made. I shou'd be most sincerely thankfull, If I cou'd be Informed of the American Method, through your kind assistance.[14]

The new consul engages in founding or attempting to found a monthly magazine,[15] he advocates the extensive planting of shade trees in New York, in short, he urges many fairly practicable ideas, nearly always designed for the public welfare.[16] During a visit to Boston to recover his two long-lost younger children, whose mother had died while Crèvecoeur was absent in France, Crèvecoeur is still alert to 'consular' opportunities, making himself acquainted with John Peck, a competent ship-builder, whom he can recommend to the French owners of the packet-line.[17]

In 1785, Crèvecoeur returned to France on leave of absence. He occupied himself in getting ready a still further-expanded French edition of *Lettres d'un Cultivateur Américain*,[18] and, as a consul and cosmopolitan in initiating a Société Gallo-Américaine, perhaps the most philosophic of Crèvecoeur's cooperative schemes, though, like many of the others, not very long-lived. This society was contemplated as "a center to which an account of everything of consequence, which is done in either country may be brought."[19] The leave of absence terminated in 1787, when Crèvecoeur sailed for America, and the society seems to have lapsed in his absence. The period from his return to New

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[14] *Letters from an American Farmer*, p. 247.

[15] Julia Post Mitchell, *St. Jean de Crèvecoeur*, p. 118.

[16] *Ibid.*, p. 119 ff. Crèvecoeur was also the early advocate of some sort of quarantine station in New York harbor.

[17] *Ibid.*, p. 128.

[18] Published at Paris in 1787, in three volumes!

[19] Julia Post Mitchell, *St. Jean de Crèvecoeur*, p. 155.

York to his final departure for France in 1790 was filled with the same sort of eager business in his office as the earlier period, — only now there is a little more worry mingled with the business, for several of his schemes are falling to pieces, notably his precious packet-line[20] His projects never did carry like those of Franklin, for some lack of genius, perhaps, in Crèvecoeur, which Franklin surely possessed

From 1790 till the end of the French Revolution, Crèvecoeur makes off from the conflict, refusing again (rather too similarly) to face the issue and take sides in this second revolution As he fled from America in 1778–1779, so now he tries to get his sons and himself well away from Paris. The sons do get away, Alexandre to Hamburg, Louis to America to do some farming on his own account[21] It is not quite just to have said that Crèvecoeur himself fled. In fact, he stayed in Paris till 1794 (though not by choice) very quietly subsisting, under the protection of his daughter's husband M Otto. He made his way as soon as possible in 1794 to Hamburg For the purpose of this paper only two more points in Crèvecoeur's life need be noted He published an important book, *Voyage dans la Haute Pensylvanie,*[22] in three large volumes, in 1801 at Paris. The book is of the same general sort as his second French edition of the *Lettres d'un Cultivateur Américain,*[23] an account of travels in the American wilderness, interlarded with philosophic reflections and what he called 'anecdotes.' Like the other projects of Crèvecoeur's old age, this book failed, because interest in America was obliterated by interest in France herself . . . He died in 1813. So ends Crèvecoeur the man of affairs, correspondent, on occasion, of Jefferson and of Franklin.

In placing Crèvecoeur beside Thoreau, this second phase of Crèvecoeur's life, the New York and Paris phase, is not so irrelevant as it seems. Without the strong social and diplomatic bent in his nature, Crèvecoeur would have been much less typical of his era Rousseau is dependent on social intercourse to an extent that he himself does not appear to realize. Franklin, too, the man of common-sense genius, rejoiced in social life and probably never passed a day in what Thoreau would have recognized as solitude. Thoreau could not conceivably have emerged from his life as the solitary or 'bachelor of nature,' as Emerson once called him,[24] and have turned to such a busy politico-social career as Crèvecoeur did after 1778 It would have seemed far worse than death to Thoreau

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[20] *St. Jean de Crèvecoeur*, p 270.

[21] *St Jean de Crèvecoeur*, pp 286, 287.

[22] The full title is· *Voyage dans la Haute Pensylvanie et dans l'État de New York*, Par un Membre adoptif de la Nation Oneida. Traduit et publie par l'auteur des Lettres d'un Cultivateur Américain. Paris, 1801.

[23] Published in 1787 in three volumes.

If we forget, for a while, Crèvecoeur's facile transformation from frontier farmer to French consul at New York, and consider him during those fifteen or twenty years on the soil, there crop out, upon our scrutiny, certain superficial similarities to the Thoreau who had so much more to say to farmers than to 'gentlemen,' so much more to record of them than of philosophers, in his journal, the Thoreau who tilled his bean-field (if not his farm) near the shores of Walden, in the midst of what was then something of a wilderness, *if not a frontier* Crèvecoeur must have grappled successfully with farming and have had to some degree Thoreau's practical knack of dealing with things — birds, insects, trees, and rocks — surveying, map-making, fencing, fruit-growing. Crèvecoeur's account of what he names a 'recreation,' bee-hunting, at the same time shows his practical knowledge

> I carefully examine whether they [the woods] abound with large trees, if so, I make a small fire on some flat stones, in a convenient place, on the fire I put some wax, close by this fire, on another stone, I drop honey in distinct drops, which I surround with small quantities of vermilion, laid on the stone, and then I retire carefully to watch whether any bees appear If there are any in that neighborhood, I rest assured that the smell of the burnt wax will unavoidably attract them, they will soon find out the honey, for they are fond of preying on that which is not their own, and in their approach they will necessarily tinge themselves with some particles of vermilion, which will adhere long to their bodies I next fix my compass, to find out their course, which they keep invariably straight, when they are returning home loaded By the assistance of my watch, I observe how long those are returning which are marked with vermilion. Thus possessed of the

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[24] Cf Emerson's biographical account *Thoreau*, 1862, in the *Atlantic Monthly* for August.

> course; and, in some measure, of the distance, which I can easily guess at, I follow the first, and seldom fail of coming to the tree where those republics are lodged I then mark it, and thus with patience, I have found out sometimes eleven swarms in a season, and it is inconceivable what quantity of honey these trees will sometimes afford [25]

Thoreau, instead of Crèvecoeur, might not only possibly but very probably have written such a lucid orderly account of a practical undertaking in the woods When Crèvecoeur forgets his fervent recommendation of the simple perfect life to record an observation or recount a process, his writing is second to that of no other of his time in America likewise, when Thoreau becomes more intent on the occurrence taking place before his eyes than on its symbolic value to humanity, he writes with the same ingenuous charm as Crèvecoeur Consider Thoreau's exposition of the methods (gleaned from practice and observation on his part) of woodcutting employed by his Canadian visitor

> He was a skilful chopper, and indulged in some flourishes and ornaments in his art He cut his trees level and close to the ground, that the sprouts which came up afterwards might be more vigorous and a sled might slide over the stumps, and instead of leaving a whole tree to support his corded wood, he would pare it away to a slender stake or splinter which you could break off with your hand at last [26]

In their capacity to write this sort of thing admirably and in their capacity to describe animals [27] or any wilderness phenomena in the same style, Thoreau and Crèvecoeur are justly to be likened to each other In almost every respect besides, the two are not only not alike but are strikingly different To be sure both were skilled surveyors, as Crèvecoeur's maps in his 1787 edition of *Lettres d'un Cultivateur Américain*, and his 1801 *Voyage dans la Haute Pensylvanie* testify — and as Thoreau's local reputation in Concord testifies As I have said, both knew, also, how to grow fruits and vegetables successfully. Both got the most satisfactory returns from farming (in Thoreau's case from being ever close to the soil, without consistent farming) in the form of spiritual exaltation. And here is, nevertheless, the great gulf between the two men, this matter of what wild nature and the soil do confer upon a man and how they confer their mighty benefits.

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[25] *Letters from an American Farmer* (New York, 1913), p 31.

[26] *Walden*, by Henry David Thoreau, published in 1854 The quotation is from the chapter named "Visitors"

[27] See Crèvecoeur's description of the combat of two snakes, *Letters from an American Farmer*, pp 179–181, and see Thoreau's description of his pursuit of a loon, in *Walden*, chap "Brute Neighbors."

Crèvecoeur is said to have been pleased when his own son Louis experimented on a frontier farm in America[28] and Crèvecoeur spent some time in his old age upon a farm in France,[29] yet he seems not to have been very firmly wedded to the soil when a different sort of life offered His best years were spent gladly in the city-life of a consul Only the year before he returned to France and entered upon his politico-social career, he had sold the completed manuscript of his first book to a publisher In that book he conveys to his readers an impression that he, Crèvecoeur, believed that farming was peculiarly the life, the profession, of virtue, that in farming subsisted the truest natural relation between God and man By 'farming,' I mean, of course, American farming in those days He assures us eloquently of the material well-being of an American farmer, the material well-being that miraculously expands into spiritual bliss

> He [the immigrant to America] begins to feel the effects of a sort of resurrection, hitherto he had not lived, but simply vegetated, he now feels himself a man, because he is treated as such, the laws of his own [native] country had overlooked him in his insignificancy, the laws of this cover him with their mantle Judge what an alteration there must arise in the mind and thoughts of this man, he begins to forget his former servitude and dependence, his heart involuntarily swells and glows, this first swell inspires him with those new thoughts that constitute an American[30]

Crèvecoeur must have discovered this effect in himself as he developed his own farm and he must have observed and corroborated his own experience by the experiences of others — men of many races, men in New England and men in Carolina, men in the immense region between those two extremes Instead of attributing this effect of farming in America to the mere practice of the simple life recommended by Rousseau, Crèvecoeur seems to believe that there is some peculiar virtue inherent in America

[28] Mitchell, *St Jean de Crèvecoeur*, pp. 286-288.
[29] *Ibid.*, p 300.
[30] *Letters from an American Farmer*, p 59.

In fact, he makes no great mystery of the inherent virtue. He makes claim in addressing his introductory *Letter from an American Farmer* to a European reader that "Here (in America) he might contemplate the very beginning and outlines of human society, which can be traced nowhere now but in this part of the world"[31]

He continues to define his thesis thus

> Here we have in some measure regained the ancient dignity of our species, our laws are simple and just, we are a race of cultivators, our civilisation is unrestrained, and therefore everything is prosperous and flourishing For my part I had rather admire the ample barn of one of our opulent farmers, who himself felled the first tree in his plantation, and was the first founder of his settlement, than study the dimensions of the temple of Ceres[32]

America is, then, not the land of a novel virtue, but a land of the primitive virtue so eloquently trumpeted by Rousseau in *Le Contrat Social* and *Émile* The 'beginnings of human society' are by no other means in any other region to be come at so authentically as by farming in America. It is not credible that Crèvecoeur could have been unacquainted, before composing his first book, with several of Rousseau's productions. Later,[33] we know that Rousseau's former intimate friend, La Comtesse d'Houdetot was one of Crèvecoeur's most constant friends and advisers Could a Frenchman of the eighteenth century with Crèvecoeur's turn for literature have missed Rousseau — even if he had been living over twenty years in the wilderness? Crèvecoeur assures us, of course, that he is a simple uncultivated man not at all fit to write "Letters" on America,[34] yet the event shows him a rather conscious artist There is something more than simplicity in this too sedulous depreciation. Methinks this farmer doth protest too much for one about to perform so deftly He says

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[31] *Ibid*, p 12

[32] *Letters from an American Farmer*, p. 12.

[33] After 1782

[34] Cf. the introductory letter of *Letters from an American Farmer*, in which Crèvecoeur allows himself to be persuaded reluctantly to undertake the "Letters"

> Had you wanted the style of the learned, the reflections of the patriot, the discussions of the politician, the curious observations of the naturalist, the pleasing garb of the man of taste, surely you would have applied to some of those men of letters with which our cities abound But since on the contrary, and for what reason I know not, you wish to correspond with a cultivator of the earth, with a simple citizen, you must receive my letters for better or worse [25]

In view of Crèvecoeur's accomplished, not to say elegant, performance in the ensuing book of "Letters" (where he cleverly manages to synthesize patriotic reflections, political discussions, natural observations, — to clothe them, besides, in the garb of sentiment and taste) we must look upon those modest protestations as elaborate artifice The artifice goes further, for the English enquirer about American civilization is a mere artistic fiction There is no reason why Crèvecoeur with his impulse to build an artistic book should not have made use of these artifices — the result justifies them — but the self-consciousness which such artifice reveals in the artist should prevent us from any longer looking upon Crèvecoeur as a delightfully ingenuous child of nature He was no such thing and his countryman Rousseau was no such thing. Crèvecoeur like Rousseau is striving for an artistic effect in which harmony of impressions must be important It is hard not to believe that the former, like his spiritual father, the latter, did not color the description, too much an artist to be an authentic pioneer Just as Rousseau has an ancestral relation to this too candid American farmer, so the farmer has a somewhat ancestral relation to Chateaubriand, though no one of them could be proved to be acquainted with another's writing They represent the thought of the same age. That they were able to report the truth of things — particularly of external nature — one comes to doubt Chateaubriand and Crèvecoeur both knew America at first hand, but did they know how average Americans of their day felt? How was it that Crèvecoeur could not enter hotly on either side in the American Revolution? An average American could not help being a patriot or a loyalist Crèvecoeur was first a man of sentiment, we must believe, and afterward an

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[25] *Ibid*, p 20

American. Seldom does he allow himself to forget this chosen pose of one who has experienced the golden age upon his farm. No doubt he did experience that swelling of heart and those overflowings of tears, and no doubt other occasional American settlers did, too[36] But there is really no reason to affirm any such mystic expansion as a representative emotion of even eighteenth-century settlers It was what got into print

On a different point, Crèvecoeur's findings carry more conviction The absolute ownership of land is, he tells us, within every industrious man's reach in America This is the root of all good in the new country, the very source of Crèvecoeur's own swellings and overflowings and of the average American settler's more phlegmatic contentment[37] Private property in land, the thought of passing on to children such an inheritance, these are subjects of most alluring contemplation to the 'American Farmer'

> From nothing to start into being, from a servant to the rank of a master, from being the slave of some despotic prince, to become a free man, invested with lands, to which every municipal blessing is annexed! What a change indeed! It is in consequence of that change that he becomes an American[38]

The 'change' here spoken of is to Crèvecoeur a change of spirit as distinctly as a change of material resources With Crèvecoeur himself, the spiritual expansion did honestly count for more than the material increase that came with tilling the soil, for Crèvecoeur was a man of sensibility, not an average European seeking refuge from overcrowded poverty Your proper Rousseauist gets his returns from nature and the soil more in the form of pleasant and profitable reflections than in the form of potatoes and cauliflowers, this, although he may be an admirable farmer, materially speaking[39] Perhaps the truest fruit of Crèvecoeur's farming days, and a typical eighteenth-century fruit it is, may be indicated by a passage from the "American Farmer"

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[36] For instance, Gilbert Imlay in his stout volume, *The Topographical Description* (1792), would have us view early American life on the soil as something not unlike the 'Golden Age'

[37] *Letters from an American Farmer*, "History of Andrew the Hebridean," pp 68 ff Andrew experiences no such ecstasies as Crèvecoeur does!

[38] *Letters from an American Farmer*, p 60

[39] As I have intimated, Crèvecoeur was a practical farmer who didn't allow golden dreams to interfere with crops. He made many shrewd agri-

> I married, and this perfectly reconciled me to my situation, my wife rendered my house all at once cheerful and pleasing, it no longer appeared gloomy and solitary as before, when I went to work in my fields I worked with more alacrity and sprightliness, *I felt that* I did not work for myself alone, and this encouraged me much My wife would often come with her knitting in her hand, and sit under the shady trees, praising the straightness of my furrows, and the docility of my horses, this swelled my heart and made everything light and pleasant, and I regretted that I had not married before [40]

And this passage must be supplemented by a glimpse of indoor bliss, as bliss came to Crèvecoeur

> When I contemplate my wife, by my fire-side, while she either spins, knits, darns, or suckles our child, I cannot describe the various emotions of love, of gratitude, of conscious pride, which thrill in my heart and often overflow in involuntary tears [41]

It must not be for an instant forgotten (and Crèvecoeur frequently reminds his readers of it), that these paternal and agrarian ecstasies, which he attributes to the American farmer as such, depend upon the principle already enunciated Crèvecoeur has no sooner pictured the bliss of his home than he adds

> The instant I enter on my own land, the bright idea of property, of exclusive right, of independence exalt my mind Precious soil, I say to myself, by what singular custom of law is it that thou wast made to constitute the riches of the freeholder? This formerly rude soil has been converted by my father into a pleasant farm, and in return it has established all our rights, on it is founded our rank, our freedom, our power as citizens, our importance as inhabitants of such a district These images I must confess I always behold with pleasure, and extend them as far as my imagination can reach [42]

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cultural observations, some of them taking effect in his "Agricola Papers," e g the article on introduction of grasses into U S. See Appendix of Mitchell's *St. Jean de Crèvecoeur*, pp 322 ff

[40] *Letters from an American Farmer*, p 22.

[41] *Ibid*, p 24 On the following page, we hear how the thrilled father contrives to carry his infant son upon his plow through the fields where "the odoriferous furrow exhilarates his (the son's!) spirits"

[42] *Letters from an American Farmer*, pp 24, 25 Crèvecoeur seems to have gone almost as far as Wordsworth in his old age did, in trusting the 'sense of property' as the first principle of good.

In short, it becomes increasingly apparent that the 'bright idea of property' rather than the mere nearness to the soil is the great American virtue in Crèvecoeur's eyes Nature is still in her eighteenth-century position as convenient servant to man, entirely satisfactory only when tamed and cultivated[43]

At this point, it is impossible longer to exclude Thoreau from the discussion of the farmer and the soil He cries out from his nineteenth-century generation partly in approval of, but more strongly in protest against, Crèvecoeur in his eighteenth-century generation Emerson and Thoreau agree that there is virtue in the direct contact with nature and with the soil Emerson has purchased a few acres comprising a house, a barn, an orchard, a garden, he even spends time in the garden, though we have reason to doubt whether the time is spent to good agricultural purpose There goes a convincing legend to the effect that Emerson's little boy remonstrated with his father for gardening, in alarm lest that father might hoe his own foot instead of the weeds! So far, Emerson attempted doggedly to realize his theory of the virtue of the soil Thoreau has paid his respects to a perhaps even deeper conviction than Emerson's of the utter need of man to touch continually nature and the soil, by isolating himself in a natural retreat at Walden and by working his bean-field near by. Every page, every record of Thoreau goes to indicate that he could literally not live without nature. There stand the fourteen volumes of 'journal' in which one wonders if there can be as many as ten pages not primarily concerned with nature If Thoreau comments on human beings they turn out to be (usually) farmers or outdoor workers of some sort;[44] if he comments on literature, it is likely to be literature about nature or 'natural' men such as those Greeks, Aeschylus and Pindar, whom Thoreau translated[45]

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[43] It would be unjust to Crèvecoeur not to note that, in his rarer moments, he was capable of looking straight in the face of nature. He found himself fascinated and horrified, on such occasions, rather than ravished by natural beauty, that is the case in his "Letter" — *On Snakes and the Humming Bird*. The duality of Crèvecoeur's attitude toward nature is brilliantly demonstrated in *Studies in Classic American Literature* (New York, 1923), by D H. Lawrence, pp 32 ff. It is, nevertheless, pretty clear that he habitually viewed nature as beneficent

[44] Thoreau's *Journal* contains more references to farmers than to any other group.

In the chapter, or rather the section, of *Walden* called "Solitude," Thoreau makes clear what he himself got out of being alone with nature (nothing to do in this case with tilling the soil) He affirms

> I have never felt lonesome, or in the least oppressed by a sense of solitude, but once, and that was a few weeks after I came to the woods, when, for an hour, I doubted if the near neighborhood of man was not essential to a serene and healthy life To be alone was something unpleasant. But I was at the same time conscious of a slight insanity in my mood, and seemed to foresee my recovery In the midst of a gentle rain, while these thoughts prevailed, I was suddenly sensible of such sweet and beneficent society in Nature, in the very pattering of the drops, and in every sound and sight around my house, an infinite and unaccountable friendliness all at once like an atmosphere sustaining me, as made the fancied advantages of human neighborhood insignificant, and I have never thought of them since

This account of Thoreau's mood and attitude seems at first to be very close to Crèvecoeur's account of the delights of a pioneer farmer But the similarity is a seeming and nothing more, for Crèvecoeur's heart-thrill and 'involuntary tears,'[46] prove always to come as a result of domestic emotions of felicity (as father or husband, that is) or as a result of the sudden realization of ownership of the land. Nature appeals to Crèvecoeur most persistently as property — the support of his family, the inheritance for his children. He speaks unmistakably in the passage quoted above.

> "This formerly rude soil," he says, "has been converted by my father into a pleasant farm, and in return it has established all our rights, on it is founded our rank, our freedom, our power as citizens, our importance as inhabitants of such a district These images I must confess I always behold with pleasure, and extend them as far as my imagination can reach for this is what may be called the true and the only philosophy of an American farmer."[47]

Occasionally, Crèvecoeur takes a snatch of pure joy in nature without reference to property, civilization, wife, or children, but rarely, and very rarely compared with Thoreau. For instance, Crèvecoeur speaks enchantingly for a few lines of "the pleasure I receive from the warblings of the birds in the spring,"[48] on occasions when he steals out before dawn to hear the earliest songs Even on such excursions there is no sign that nature communicated such a mystic beneficence to him as Thoreau records in the foregoing passage and not a few others Crèvecoeur views wild nature with keen senses and immense curiosity, but he prefers to meditate upon the soil "advantageous for the emolument of human nature"[49]

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[45] In the collected works of Thoreau are to be found a translation of *Prometheus Bound* by Aeschylus, and of several Pindaric Odes.

[46] *Letters from an American Farmer*, pp. 24 ff

[47] *Ibid*, pp. 25. Cf p 323.

But what has Thoreau to reply to the eighteenth-century lover of nature for its use to support human beings? Something very positive Farming and farms in nineteenth-century New England were very different from farming and farms in New York in the eighteenth-century And Thoreau had no wife and children to require the support of a farm Though we discount all this, Thoreau's comment is significant

> I see young men, my townsmen, whose misfortune it is to have inherited farms, houses, barns, cattle, and farming tools, for these are more easily acquired than got rid of How many a poor immortal soul have I met well-nigh crushed and smothered under its load, creeping down the road of life, pushing before it a barn seventy-five feet by forty, its Augean stables never cleansed, and one hundred acres of land, tillage, mowing, pasture, and wood-lot! The portionless, who struggle with no such unnecessary inherited encumbrances, find it labor enough to subdue and cultivate a few cubic feet of flesh[50]

Now the profoundest gulf between Crèvecoeur and Thoreau and between the periods they represent begins to appear. Thoreau, also, values nature and the soil, not, however, for the material support they afford, but chiefly for the inner discipline, stimulation, at best the revelation, that they may afford Crèvecoeur's day seldom evinced much anxiety over its interior processes, that is, its inner life. It was generally agreed at that time that human nature, inner human nature, was so well arranged as to need little or no attention Fifty years after Crèvecoeur, in Thoreau's day, there had developed a widespread uneasiness and concern over the inner life. What goes by the name of introspection began to preoccupy the people who counted in thought and art[51] — and a great number of others who counted as the public for the thinkers and artists Thoreau will have us eschew, as far as possible, many of those things which seemed most incontrovertibly good to Crèvecoeur Let us not be slaves to our land, or our houses, or to our clothes, or to our food, or to the organizations to safeguard other people by good-natured charities Beware of enslaving yourself to philanthropic drives or political moves for that (to Thoreau's mind) is the enslavement of the spirit beside which the enslavement of a black African's body is as nothing! This carries us beyond nature and the soil, yet it shows how completely Thoreau is at variance not only with Crèvecoeur the farmer but equally with Crèvecoeur the endlessly busy man of projects, of societies, of inventions, of politics — Crèvecoeur, the lesser Franklin!

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[48] *Ibid*, p 33

[49] "Crèvecoeur on the Susquehanna," *Yale Review*, April, 1925, p 571 This is a series of selections from Crèvecoeur's English writings hitherto unpublished The material may represent the contemplated second series of *Letters from an American Farmer* See advertisement to the first edition.

[50] Thoreau's *Walden*, section called "Economy"

Crèvecoeur and Thoreau were both inquisitive, eager travellers of the wilds But are they alike at even this point? Crèvecoeur, to judge from the astonishing fashion in which he kept expanding the accounts of his American wanderings, was an insatiable explorer We feel that the interest in the American panorama ultimately obscured the early interest in the farm The first London edition of Crèvecoeur's book impresses any reader most powerfully as a picture of the life of an America of farmers The first French edition,[52] while it contains nearly all the material of the London edition, adds as much again, it is, indeed, a two-volume production The farm and farmer lose their prominence to a certain extent by reason of the bulk of additional panoramic description. In the first edition, as I have mentioned previously, with what seemed conscious artistry, Crèvecoeur gave an account of a typical northern region, Nantucket, of a typical central region, that of his own New York farm; of a typical southern region, near 'Charles-town,' Carolina The material that doubles the length of the second edition consists, in large part, of Crèvecoeur's further excursions,[53] not of his further development of his own soil. Crèvecoeur's predilection for travel is unpleasantly clear. He offers a conglomerate of trips to Canada, Isle Saint-Jean, Nova Scotia, New Foundland, Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Bermuda, and Jamaica! The 'cultivateur' is submerged in the 'voyageur' Not that Crèvecoeur ceased at all to concern himself with farms as an observer and philosopher, to the last year of his life (and he was then on a farm in France) Crèvecoeur was immensely addicted to reflections on farming The 'voyageur' does, nevertheless, triumph in his last French edition [54] (expanded now to three volumes!) of the *Cultivateur Américain*, and in his very last compilation of another three volumes, significantly entitled, *Voyage dans la Haute Pensylvanie et dans l'État de New York* In these books we get treatises on such remote regions (whether Crèvecoeur wrote from ocular proof or hearsay!)as that of the 'Ohyo' River, of 'Kentuckey,' [55] of Niagara Falls, of Lake Ontario, of Lake Superior, of Delaware, of the Mississippi from St. Louis to New Orleans, of Georgia, of Louisiana and the delta of the Mississippi. [56] This sounds like the very dissipation of travelling when one considers what it meant in the middle of the eighteenth century.

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[51] Perhaps Tolstoi is the most notable example of the passionate, sometimes morbid, introspection of the nineteenth century. Tolstoi's book *My Confession* is of nineteenth-century temper, Rousseau's *Confessions* of eighteenth-century

[52] *Lettres d'un Cultivateur Américain*, Paris, 1784

Now Thoreau made excursions to Maine, to Cape Cod, to Minnesota, even, but in Thoreau's century all these trips were comparatively brief The strongest impulse Thoreau seems to have extracted from these brief aberrations was to confine himself ever more closely to his very own region in and about Concord, Massachusetts. The inference is not that Thoreau disliked travel, but that he got profit from it in proportion as the journey was short so he could pause to note everything Probably one of Thoreau's walks about Walden Pond had a travel-content about equivalent to that of a vulgar summer about Europe Thoreau was inclined to believe that most things worth observing could be observed in the restricted area of Concord, provided one watched patiently and examined minutely His unmeasured travels were of the spiritual sort and he was always conscious of vast distances there

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[53] None of these later editions can compare for design and artistic effect with the nicely balanced original

[54] *Lettres d'un Cultivateur Américain*, trois tomes, Paris, 1787.

[55] *Ibid* The Ohio River and Kentucky are the notable geographic additions in the 1787 issue

[56] These last items are in *Voyage dans la Haute Pensylvanie.*

> What sort of space is that which separates a man from his fellows and makes him solitary? I have found that no exertion of the legs can bring two minds much nearer to one another We are for the most part more lonely when we go abroad among men than when we stay in our chambers [57]

Such was Thoreau's experience; such was not Crèvecoeur's experience. The mere fact that they both travelled considerable regions of the northern United States is not going to establish any similarity beween the two

The strange thing is that Crèvecoeur speaks always with such passionate approbation and abandon of farming, while he proceeds to center his attention upon his former travels and his later international projects The other strange thing is that Thoreau, who reveals in his journal a very disillusioned set of views about farmers and farming, passes his life, by choice, in closer contact by far with the Concord farmers than with the Concord preachers or teachers or doctors or lawyers.

Living with Crèvecoeur's books intimately for a period, living, that is, with his words in one's mind, leads to something pretty near to a conviction not of insincerity on his part but of relative superficiality. His charm, his grace, his artistry do not deteriorate on familiarity, perhaps, but his integrity crumbles a little; his nature lacks depth and impressiveness.

Living with Thoreau's *Journal* breeds a very different conviction. The reader or student of Thoreau is always aware of a profound and positive personality, one who insists on facing all questions out to an answer — if there be any answer. One indubitable sign of Thoreau's potent nature is that no student of his work can depart unmoved. On the lips of the departing is either eloquent praise or utter damnation of Thoreau. Both attitudes bear witness to a genuineness in Thoreau And Thoreau's word on farmers and farms and farming shall be the last word rather than Crèvecoeur's Wisely, Thoreau propounds the question that Crèvecoeur forgot to consider Thoreau exclaims rather than questions

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[57] Thoreau's *Walden*, section entitled "Solitude"

"How rare to meet a farmer who is a man of sentiment!"[58] But Crèvecoeur had so inflated his own sentiments as to attribute them to farmers as a class He was precisely this exceptional farmer of sentiment

Thoreau amplifies by picturing the household of the average farmer in a style which leads to the question whether Crèvecoeur's picture of his domestic bliss as a farmer was not far more exceptional than typical Says Thoreau

> How much oxen are like farmers generally, and cows like farmers' wives! and young steers and heifers like farmers' boys and girls! The farmer is ox-like in his thought, in his walk, in his strength, in his trustworthiness, in his taste[59]

Is it merely that farmers have changed so and that farming has changed so between 1750 and 1850? Hardly likely, though there were notable changes It is hard to doubt — with all changes — that Thoreau has given a more veracious picture here of even the farmers of 1750 than ever Crèvecoeur did Crèvecoeur's great fault is in posing as a representative of the profession.

Again, Thoreau affirms in his *Journal*.

> I must not lose any of my freedom by being a farmer and landholder. . . The farmer's muscles are rigid He can do one thing long, not many well His pace seems determined henceforth, he never quickens it A very rigid Nemesis is his fate When the right wind blows or a star calls, I can leave this arable or grass ground, without making a will or settling my estate[60]

In his astonishingly exceptional fashion, Crèvecoeur appears to have transcended this farmer's Nemesis, for he does many things well, and follows (if not the call of a wind or a star!) birds, bees and snakes, though his profession be farming Has the *typical* American farmer ever transcended his fate thus? Exceptional St John de Crèvecoeur! Thoreau was by comparison a cynically realistic observer of farmers He agrees with Crèvecoeur that the taming of the soil is more heroic than war[61] But Thoreau dislikes or almost despises the scientifically perfect farmer whom Crèvecoeur clearly envisions all his life[62] In *Walden*, Thoreau says, perhaps not quite consistently with certain other observations of his on farmers, but, at any rate, he is moved to say, and says "Farmers are respectable and interesting to me in proportion as they are poor, -- poor farmers"[63] Again he drives the same point home from another angle

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[58] Thoreau's *Journal* (Boston and New York, 1906), Vol. II, p 332.

[59] *Ibid*, Vol. II, p 453.

[60] Thoreau's *Journal*, Vol I, pp 241, 242.

> The journals think they cannot say too much on improvements in husbandry It is a safe theme, like piety But for me, as for one of these farms brushed up, — a model farm, — I had as lief see a patent churn and a man turning it. It is simply a place where somebody is making money[64]

Though it would be altogether unfair to Crèvecoeur to say that all he cared for as a farmer was 'somebody making money,' the tone of his pronouncements about 'the bright idea of property' leaves no doubt that the 'emolument' from the soil is fundamental even to his expansion and swelling of heart This notion Thoreau scorns, while Thoreau's reason for scorn is so remote from the habits of thought of Crèvecoeur and the majority of his literary contemporaries that they would have been bewildered and unable to grasp it Thoreau the transcendentalist, the Emersonian Thoreau, was confident that a life close to nature and the soil could, at its best, yield more of spiritual truth and religious health than any other life. He knew that the man who lived in the open — that is, on a farm — might actually approach the great Spirit of the universe, the Oversoul, and might be penetrated by that Spirit more readily than any other man Beyond this transcendental certitude about the magnificent possibilities for the inner life of a farmer, Thoreau the individual — a far shrewder and more realistic seer than any other transcendentalist (not forgetting Emerson or Wordsworth or Carlyle) — saw with crystal clarity just what farmers actually turned out to be, when you associated with them for days, weeks, months, years! Beyond a doubt the flourishing, scientific, improved farmers were divorced from any possible spiritual benefits of the sort Thoreau prized The poor farmers, for their part, are ox-like, stolid and stunned, yet Thoreau (who ought on theory to condemn them) finds these farmers of the second sort the most engrossing persons, as a class, in his world He alternately gibes at them and admires them One page of the *Journal* informs us that· "The farmer increases the extent of the habitable earth He makes soil That is an honorable occupation "[65] Another page informs us that Thoreau has just had "the slowness and dullness of farmers reconfirmed "[66] If Crèvecoeur may be said to be compounded out of some measure of the stuff of Rousseau on one side, and of the stuff of Franklin on the other, Thoreau is no less a remarkable compound of later types of idealist and realist But, as I began by saying, Thoreau is too individual to be analyzed into terms of other writers or doers To try to pack the essential divergence of these two complex men in their attitude toward nature and the soil into one sentence is hazardous even to the point of recklessness With a full sense of peril, then, let it be proposed that Crèvecoeur viewed nature with sentiments of curiosity, sympathy, approval; and Thoreau viewed nature with the very passion (sometimes baffled) of religion A man of sentiment is going — if like Crèvecoeur his keenness of observation reveals to him that nature does not always fit sentiments — to disregard and blur and forget the ugly and intrusive facts. A man of passion — with equal keenness of observation — is going to pursue and scrutinize every ugly, intrusive, discordant fact, to understand each, to rebel and fight. Crèvecoeur spreads icing over those portions of the cake of nature that are either burned or soggy, his impulse to avert his eyes or to run away from the disturbing elements in human affairs on the occasions of the American and the French revolutions[67] confirms the earlier estimate of Crèvecoeur-the-farmer as a man of sentiment only Thoreau, being put to a similar test in the affair of John Brown's effort at Harper's Ferry, spoke and acted with vehement conviction in justification of John Brown at a time when such overt action and speech were expected to lead both to imprisonment and (before that) to mob violence — the New England lynching of those days One might multiply instances from the lives of both men as they were related to people rather than to nature, still the unmistakable verdict would have to be — Crèvecoeur, man of sentiment, albeit ingenious and practical, Thoreau, man of passion, albeit rebelliously shrewd[68]

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[61] See the fine paragraph on this subject in the *Journal*, Vol IV, pp 483, 484 The concluding clause is memorable ". and so the soil was tamed"

[62] Crèvecoeur is copious with schemes to help the farmers in France and America during the years of his consulship Material benefits are naturally enough his obvious concern in farming

[63] Thoreau's *Walden*, section on "The Ponds"

[64] Thoreau's *Journal*, Vol X, p. 286

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[65] Thoreau's *Journal*, Vol. III, p 329.

[66] *Ibid*, Vol. VI, p 20

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[67] *Letters from an American Farmer*, Letter XII, "Distresses of a Frontier Man" Portions of this letter are most unedifying in their display of panic fear It is hardly a thing to display! He concludes (page 205) that "Self-preservation, therefore, the rule of nature, seems to be the best rule of conduct "

[68] No complete idea of Thoreau can be achieved without reading his lectures *Civil Disobedience* and *A Plea for Captain John Brown* In the former lecture, Thoreau ardently declares "Under a government which imprisons any unjustly, the true place for a just man is also a prison" How curiously that would ring on the ear of J Hector St. John de Crèvecoeur

# THE USE OF THE WORD 'DYNAMIC' IN PSYCHOLOGICAL LITERATURE

C E RAGSDALE

THIS paper is an outgrowth of an attempt to review the recent literature on 'dynamic psychology' The writer began with three recent books Dom Verner Thomas Moore, *Dynamic Psychology* (Lippincott, 1924), Robert S Woodworth, *Dynamic Psychology* (Columbia University Press, 1918), John T MacCurdy, *Problems in Dynamic Psychology* (Macmillan, 1922) Two of these books use the expression as a title and it appears in the third title. A book by Arthur I Gates, *Psychology for Students of Education* (Macmillan, 1923) was also included, since it makes frequent use of the term 'dynamic' It was believed that there would be some agreement between these books upon the material which should be designated by that name The word 'dynamic' has not been generally used by other writers. The results of the investigation have been rather surprising

MacCurdy states that "Dynamic Psychology is a useful term which covers the study of instincts, motives, emotions and imaginative or autistic thinking as opposed to the more static functions of attention, perception, memory and similar conscious logical processes." By way of explanation he says "The static intellectual functions of the mind are like the mechanisms of an automobile, the emotional or instinctive functions are like its thermo-dynamics." His definition is open to serious objection Webster's dictionary defines *static* as follows "pertaining to bodies at rest or in equilibrium resting, acting by mere weight, as statical pressure." *Function*, on the other hand, means, in a general sense, the doing, executing or performing of anything; discharge, performance. Therefore to speak of 'static functions' is contradictory and means exactly nothing

Passing from this contradictory definition to the material included in his book, we find that for him dynamic psychology means a study of the unconscious The motives of human activity lie in the unconscious, which gets its origin and driving force from the instincts In discussing the "dynamics of suggestion and psychoanalysis," MacCurdy states that ideally "Cure rests not on an abolition of symptoms such as suggestion may affect, but on a redirection of unconscious strivings which suggestion does not attempt to produce, and which, in fact, occurs spontaneously" Concerning its method, he thinks that psychoanalysis treats "Objectively, but as purely mental, the most dynamic factors in human life" 'Dynamic,' refers, therefore, to unconscious forces.

Choice between different possible activities is not a matter of intelligence, else man would be in a paralysis of indecision "This choice-function — this motivation — is derived from the instinctive part of the human psyche and intelligence is merely the instrument of instinct" Since man foresees his behavior, his instinctive reactions appear as motives rather than as simple reactions, except in emergencies "The study of man's emergency behavior would be an extremely simple problem. The real task of psychology is the discovery and analysis of instinct-motivation, the form of instinct expression peculiar to man" "The structure of the motivation requires memory and ideation with instinct to supply the driving force The all important dynamic elements are unconscious ideas charged with instinctive energy, i e, instinct-motivations" (Freudian wish)

Woodworth considers that dynamic psychology is a study of the drives of conduct, but he assigns relatively little importance to the unconscious The point of view that is interested in cause and effect, mental dynamics, is the common-sense point of view in psychology and is most in evidence in the history of psychology. Neither consciousness nor behavior nor the two together provide a coherent system, consciousness leaves out many things below its threshold; behavior leaves out much between stimulus and reaction. "But the essential thing is to keep the dynamic point of view, and be working always toward a clearer view of the mental side of vital activity, refusing to be contented with the fragmentary views offered us by the exclusive students of either consciousness or behavior, but endeavoring to utilize the results of both these parties, and the results of brain physiology as well, for an understanding of the complete processes of mental activity and development"

According to Woodworth the two main problems of dynamic psychology are (1) mechanism and (2) drive They correspond to the questions How? and Why? In a simple reflex this distinction means little, in more complicated behavior, the problem is to get from drive as an external stimulus to drive as an internal motive. "It is therefore a very important fact, for our purpose, that a nerve center, aroused to activity, does not in all cases relapse into quiescence, after a momentary discharge Its state of activity may outlast the stimulus that aroused it, and this residual activity in one center may act as a drive to another center" In another place he says "The great aim of the book is, that is to say, to attempt to show that any mechanism — except perhaps some of the most rudimentary that give the simple reflexes — once it is aroused, is capable of furnishing its own drive and also of lending drive to other connected mechanisms" Dynamic psychology is, therefore, a study of mechanisms and their drives, but these include acquired as well as instinctive mechanisms and drives, they include conscious as well as unconscious mechanisms

Instead of being a subdivision of psychology, as MacCurdy believes, dynamic psychology, in Woodworth's opinion, is an all-inclusive term, embracing a study of consciousness, of behavior, as well as things usually omitted from the study of these two In his book he discusses the historical development of psychology, its problems and methods, man's native and acquired equipment, selection and control, originality, abnormal and social behavior This list includes practically everything usually found in a general text on psychology except the sensory processes as such. He identifies dynamic psychology with all psychology in the statment "A dynamic psychology must utilize the observations of consciousness and behavior as indications of the workings of the mind, and that, in spite of formal definitions to the contrary, is what psychologists have been trying to accomplish since the beginning" His book is an argument for a point of view, for interpretation of phenomena in terms of causal relationship; it is not a systematic presentation of any particular portion of psychology, nor a plea for any particular method

Moore tells us in the Preface to his book that it presents the essentials of a course in psychology that will give the student "(*a*) an insight into the modern trends in psychology, (*b*) a foundation for a practical understanding of his own inner life that will be of assistance to him in the solution of the mental difficulties that continually arise in the course of an ordinary existence, and (*c*) an introduction to the clinical problems of psychology that will open the way to an appreciation of borderline mental cases and a technique for handling them, should a medical training lead him further into the field" He presents the material usually found in texts on psychology with the exception of the sensory processes as such and with the addition of several chapters on psychoanalysis and psychotherapy He defines psychology as "the science of human personality," with the further explanation that "what characterizes human personality most specifically is its mode of conscious behavior" He does not attempt to justify his use of the word 'dynamic' in the title and uses the word in only one place in the text; "It is necessary to analyze consciousness before we can attempt to obtain that synthetic knowledge which gives us that insight into the workings of any individual mind Hence it is necessary, even in dynamic psychology, to know something about the elements of our mental life." By dynamic psychology, he apparently means "synthetic knowledge which gives us an insight into the workings of any individual mind" Moore seemingly wishes to emphasize the practical value of psychology in enabling the individual to understand and direct his own mental life or the mental life of others, and chooses the word 'dynamic' to express that aim.

Gates uses the word primarily in connection with instinct.

He writes of the "dynamic rôle of instinct in habit formation," meaning that instinct furnishes the motive force which leads to habit formation The instincts impel to activity, and if the situation is novel, the result is learning "The sex instincts, self-assertion, hoarding and many others . also act as drives like hunger, although differences in strength are admitted Altogether they form the fundamental dynamic forces which guide human conduct." 'Dynamic' thus refers at the same time to a *driving* force and a *directing* agency In his Preface he says that "A relatively large amount of space is given to the mechanics and dynamics of human nature" Does that mean that possibly some day we may expect some psychologist to write a text on "Mechanical Psychology" as a companion to the books of Woodworth, MacCurdy and Moore?

These writers, therefore, do not agree upon any particular subdivision of the general field of psychology, nor do they emphasize any particular psychological method The thing in common is rather an aim Psychology should be studied, not for its own sake, but rather for its effect upon our lives as individuals and as social beings Dynamic (meaning, pertaining to power) is used by them as a synonym for forceful (meaning, acting with power). Psychology is becoming popular with the man on the street and in business He is not interested in the things which can be hit upon by the arm-chair philosopher or the 'experimental' psychologist in his laboratory. He is interested in things which are found in the social life, in the home, in school, in commerce, in literature, in war, in politics, in religion He wants to understand the things which make people rejoicè and weep, buy and sell, fight and love, sit for hours in the library or in the classroom He is concerned with the practical affairs of living. Dynamic psychology, meaning psychology which "acts with power" upon our individual and social life, might be expected to appeal to him, that is indeed just what he thinks psychology ought to do He wants action; accordingly our 'dynamic psychologists' attempt to give it to him — in the title of their books at least

Dynamic psychology, then, is merely general psychology, with the — to the ordinary man — less interesting parts left out, it is general psychology popularized and, to a certain extent, applied to the problems of living MacCurdy recognizes this fact when he says "Dynamic psychology is a relatively new science which has grown up from the observations and speculations of sociologists, anthropologists, criminologists, neurologists and psychiatrists (to a less extent from the work of the psychologist with normal man)" Woodworth recognizes it when he puts together a series of more or less popular lectures under the heading of dynamic psychology Moore is avowedly writing a book which is to be used as a guide in practical living Gates is writing a book for teachers when he talks of the mechanics and dynamics of human nature It seems highly probable that the word 'dynamic' is introduced into such discussions as a catch-word rather than for its intrinsic meaning It is intended to catch the popular fancy Its legitimate use would seem to be to emphasize the fact that psychology is a study of processes, or functions, or activities rather than a study of lifeless, inactive material.

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# SOME PRELIMINARY STUDIES IN REASONING

E B. SKAGGS

FEW experimental psychologists are at all content with the usual textbook treatment of reasoning What are the 'earmarks' of reasoning? Is there something unique in our association processes during reasoning, or is reasoning to be distinguished only by an end result, an attitude toward the last mental process or content? This discontent with the present logical exposition of reasoning started the writer on the investigation herein reported Many preliminary problems at once presented themselves, however, and it became evident that their settlement was necessary before the more fundamental questions could be handled The result is that the work herein reported deals more with these superficial problems, perhaps, than with the more fundamental problem, "What is it that makes reasoning reasoning?" An attempt has been made to obtain some light upon the following problems (1) Is there any correlation between ability to solve different kinds of problems, that is to say, if a person is a good reasoner in one kind of problem will he be good in another, if his past experience is adequate? (2) If one compares so-called 'concrete performance' and 'abstract reasoning' tests, what will one find as to the inter- and intra-correlations for these groups? (3) Are there any sex differences indicated? (4) To what extent is the number of moves made in a performance test indicative of the time taken and vice versa?

## I

Using the popular classification of concrete and abstract, the writer, with the assistance of Mr. A. W Reichert, a college senior majoring in psychology, arranged a series of tests into two groups, which we shall designate as Group I, abstract reasoning tests, and Group II, concrete reasoning tests The nature of these tests will be described shortly They were given to students in the writer's elementary psychology classes The subjects were fairly representative college students They were selected at random and, to judge by the distribution of their psychology grades and their distribution of scores on the tests, they appear representative of the larger group The abstract tests (Tests I, II, III, IV and V) were made under small group conditions, not more than twenty students being permitted to a group The concrete reasoning tests (Tests VI, VII, VIII and IX) were done individually Mr. Reichert used thirty-eight persons, all men, in his work The writer used one hundred and eighteen students, although in only a few instances did all these persons participate In presenting the tabulated figures we have specified the number of cases and the number of men and women used

The students were told frankly what the tests were about and asked to give their utmost efforts to follow directions The writer feels safe in asserting that the subjects entered into the "spirit of the thing" with apparently keen interest and effort We tried to eliminate fatigue by giving five to ten minutes of rest after each test. Of necessity, all tests were done in the afternoon. Tests in Group II were given at approximately the same time of day as those of Group I The writer rotated the order of the tests for each of his small groups, while Mr. Reichert gave the tests in the order (reading down) given in Table III No subject did the tests who reported himself or herself as being fatigued or indisposed.

We are aware of many objections to, or possible criticisms of, data herein reported and the suggestions made upon the basis of their consideration. With the material at hand we have tried, however, to control conditions as best we could. Only raw correlation coefficients are reported because we have chosen to risk all upon the validity of the data themselves The results must stand or fall upon the basis of control of conditions rather than mathematical 'patching up' One must go slowly in adducing generalizations from the data because, at best, the measuring instruments are crude From the standpoint of ideal measuring scales, our tests may be severely criticised both as regards the arbitrariness of their units and the uncertainty of their zero points

The following tests or 'problem situations' were used. As most of them are well known we shall be very brief in describing them

### GROUP I ABSTRACT REASONING

I *Thurstone Reasoning Syllogism Tests Series A* — The subject is given *four minutes to do as many as possible All subjects are warned to* think each problem through 'in their heads' and then to indicate whether the conclusion is warranted or not No making of marks of any kind by pencil was permitted (Of course we could not prohibit the 'wiggling of the tongue,' 'twisting the fingers,' and such actions These things were done and really amount to making marks )

SAMPLE Silver is heavier than iron,
Copper is lighter than silver,
Therefore copper is heavier than iron Right. Wrong

II *Thurstone Reasoning Syllogism Tests Series B* — The subject is given six minutes to do as many tests as possible This test is very similar to the preceding, but the *majority of subjects insist that it is harder* The same names of persons occur over and over in each test and this seems to be the most confusing element

SAMPLE Brown is taller than Jones,
Brown is shorter than Smith,
Therefore Jones is taller than Smith Right Wrong.

III. *Number Plan Completion Test* — This is the well-known test No 6, form 6, of the Army Alpha tests The subject is given five minutes in which to work as many problems as possible

IV *Arithmetic Reasoning Problems* — These are the arithmetic tests taken from the Army Alpha tests, test No 2, form 6.

V *Griffitts' Constructive Visual Imagination Tests Series B* — This is an unpublished series of tests constructed by C H Griffitts, University of Michigan, for work on imagery The writer considers them first-class 'reasoning tests' and so has incorporated them here The subject is given ten minutes.

SAMPLE Description — Two columns of geometrical figures are drawn on a page. Opposite each geometrical figure are the directions Thus opposite one figure, a square, are the instructions "Draw two lines dividing the square into one triangle and two four-sided figures"

## GROUP II. CONCRETE REASONING

VI. *The Healy Construction Puzzle B*[1] — This is a formboard in which five figures have been cut out and into which eleven pieces can, by proper arrangement, be fitted The subject is told to replace all the pieces as soon as possible

VII *Dearborn Formboard Construction Test*[2] — The problem presented here is the same as problem C given in the Army Performance Tests The subject must replace the extra blocks in the form as soon as possible and in the smallest number of moves

VIII *A Matching of Triangles Test* — The writer constructed this test to be used in another investigation, but incorporated it into this series for reasons which will be explained later Sixteen small isosceles triangles are drawn, four to a row, upon a white cardboard whose dimensions are 12 by 12 inches On each of sixteen separate cards, 3½ by 4 inches, is drawn a triangle identical to one which is on the large form[3] A glass covers the large form The subject must take up each card, one by one, in the left hand, and, holding it in a specified place at the upper left-hand corner of the large form, find the one it matches best Accuracy was stressed and time considered unimportant

IX. *Knox Diamond Construction Test* — This is another construction or completion puzzle Six pieces must be so arranged that all will fit into the diamond form Time and error records were taken

## II

With regard to the problem of correlations between the tests, Tables I, II and III summarize our findings. Table I gives the inter-correlations between the various tests for the combined data obtained from men and women. Table II presents the results for men alone. Table III is the result of separate research carried on by Mr. A. W. Reichert. Only men were used in this last study.

The second entry in each group of numbers gives the P. E. values of r. The figures in parentheses represent the number of cases upon which r is based.

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[1] See catalogue, C. H Stoelting Co., Chicago, for a picture of this test.

[2] See page 108, *Army Mental Tests*, by Yoakum and Yerkes.

[3] Each triangle correctly matched is counted as one unit However, when weighed by giving them their S. D values according to difficulty, some are very easy and some very difficult Several are equal in difficulty and, when scaled, large gaps are present The test is thus only a crude measuring instrument but we had no time for further work with the scale.

## TABLE I

### DATA OF TESTS FOR BOTH MEN AND WOMEN

| | Thurstone Syllogism Test A | Thurstone Syllogism Test B | Number Plan Completion Test | Arithmetic Reasoning Test | Griffitts' C V I Test B | Healy Construction Puzzle B |
|---|---|---|---|---|---|---|
| Thurstone Syllogism Test B | 430<br>0504<br>(118) | | | | | |
| Number Plan Completion Test | 303<br>0562<br>(118) | 380<br>0520<br>(118) | | | | |
| Arithmetic Reasoning Test | 670<br>0340<br>(118) | 296<br>0560<br>(117) | 710<br>0301<br>(37) | | | |
| Griffitts' C V I Test B | 540<br>0576<br>(68) | 205<br>0780<br>(67) | 500<br>0603<br>(68) | 250<br>0763<br>(66) | | |
| Healy Construction Puzzle B | 275<br>0951<br>(42) | 034<br>1045<br>(43) | 557<br>0710<br>(42) | 040<br>1030<br>(42) | 107<br>1005<br>(41) | |
| Matching Triangles Test | 155<br>0938<br>(43) | – 004<br>1005<br>(43) | 198<br>1005<br>(43) | 027<br>1005<br>(43) | 070<br>0950<br>(45) | 289<br>0870<br>(46) |

## TABLE II

### Data of Tests For Men Only

| | Thurstone Syllogism Test A | Thurstone Syllogism Test B | Number Plan Completion Test | Arithmetical Reasoning Test | Griffitts' C V I Test B | Healy Construction Puzzle B |
|---|---|---|---|---|---|---|
| Thurstone Syllogism Test B | 367<br>0737<br>(62) | | | | | |
| Number Plan Completion Test | 214<br>0797<br>(63) | 345<br>0437<br>(63) | | | | |
| Arithmetical Reasoning Test | 240<br>0355<br>(63) | 268<br>0777<br>(63) | 500<br>0630<br>(64) | | | |
| Griffitts' C V I Test B | 307<br>0938<br>(41) | 171<br>1022<br>(41) | 016<br>1005<br>(43) | 520<br>0737<br>(42) | | |
| Healy Construction Puzzle B | 300<br>1140<br>(31) | 024<br>1147<br>(31) | 147<br>1020<br>(31) | - 26<br>1147<br>(31) | - 210<br>1139<br>(32) | |
| Matching Triangles Test | 051<br>1139<br>(32) | 045<br>1150<br>(32) | 019<br>1200<br>(32) | 014<br>1139<br>(32) | 023<br>1200<br>(31) | 103<br>1159<br>(32) |

## TABLE III

### DATA OF TESTS FOR MEN ONLY

This table was compiled by Mr A W Reichert In each instance the number of students examined was thirty-eight

| | General Intelligence | Thurstone A | Thurstone B | Number Plan Completion | Arithmetical Reasoning | Healy Puzzle Construction B | Dearborn Form Board |
|---|---|---|---|---|---|---|---|
| Thurstone A | 331<br>1010 | | | | | | |
| Thurstone B | 309<br>0930 | 860<br>0280 | | | | | |
| Number Plan Completion | 503<br>0800 | 118<br>1090 | 250<br>1010 | | | | |
| Arithmetical Reasoning | 385<br>0930 | 201<br>1090 | 200<br>1090 | 511<br>0800 | | | |
| Healy Puzzle Construction B | 288<br>1000 | 024<br>1090 | - 027<br>1090 | 367<br>0930 | 193<br>1090 | | |
| Dearborn Form Board | 382<br>0930 | 356<br>0920 | 237<br>1010 | 430<br>0870 | - 005<br>1090 | 389<br>0930 | |
| Knox Diamond Form Test | 311<br>0960 | 090<br>1090 | - 101<br>1080 | 071<br>1090 | - 133<br>1090 | 355<br>0930 | 565<br>0740 |

A study of the Tables indicates several interesting and suggestive conditions

(1) One finds a fairly high intra-correlation within the group of abstract reasoning tests  We have taken the average r values in each of the three Tables and present the following results.

## TABLE IV

### Mean Intra-correlation Values

| | Range | Number of r values | Intra-correlation value |
|---|---|---|---|
| Table I | 205- 710 | 10 | 4284 |
| Table II | 016- 520 | 10 | 2948 |
| Table II * | 214- 520 | 8 | 3336 |
| Table III | 118†- 860 | 6 | 3567 |

* With two very extreme r values removed, namely, 016 and 171

† The r value of 118 is probably accidental and perhaps should not be considered  This would raise the average

The average r value for all three tables combined is 3605, which is obtained by dividing 9.372 (total of r values) by 26 (number of cases of r values)

(2) Inspecting the data with regard to the intra-correlations within the concrete group of tests (Group II), we find again a consistent and fairly high correlation within the Group·

Table III (which alone can be used here): The mean intra-correlation value is .4363, being based upon the three r values, .389 .355 and .565

(3) If we compare the intra-correlations between these two groups we find expressed a positive relationship, but in all cases it is very small  The following figures indicate the situation.

Table I. Mean r value between Healy Puzzle B and the tests of Group I is 2026. (This is based upon the values, 275, 034, 557, 040 and 107. The mean value would be much smaller if we eliminate the value 557, which is probably accidental )

TABLE II Mean r value between Healy Puzzle B and other tests of Group I is 0783 (This is based on values 300, 024, 147 and the negative values - 260 and - 210)

TABLE III Mean r value between Group I and
Healy Puzzle B is 1392, based upon the values 024, - 027, 367 and 193,
Dearborn Board is 2812, based upon the values 382, 256, 237, 450, and - 005 (Note that the Dearborn formboard correlates more highly than any other of the test of Group II with Group I),
Knox Diamond Frame is 0476, based upon the values 311, 090, - 101, - 071 and - 133

The average for all r values between Groups I and II is found to be 1560

There remains the much more difficult problem of interpreting these results We offer the following explanations and suggestions for what they are worth The common-sense grouping of these tests is justified, to some extent at least, by the correlation coefficients The fact that each group gives a larger intra-correlation than the inter-correlation seems significant It at once suggests that the tests involve different capacities This might, on the surface, argue for different kinds of reasoning On the other hand the fact that there is positive correlation between the two groups makes one suspect that some one or more common factors are involved.

We believe that the lack of high correlation between the two groups of tests may be explained in several ways. In the concrete tests one notes that the subject may solve his problem by mere trial and error in the usual sense of the term While most such procedures will result in long times and many moves, there are enough 'accidental' successes in a short time and with few moves to lower correlation values. In addition to this, however, these groups of tests, as here considered, might involve two extremes or types of capacity In other words the two groups of tests either differ by a wide gap in a scale of degree or they may be actually different in kind In the concrete tests the situation is always present in a perceptual form, whereas in the abstract tests the situation must be represented in imagination. So far as there are any great differences between the processes involved in the two groups, we believe that they lie just here It is easy to hold in memory a visual perception of a triangle, but very difficult to hold in mind an imagined triangle.

The training effects, the difference in the backgrounds of experience, on the part of the subjects might enter into the matter also While we tried to use tests which would involve a fairly similar background of experiences, we cannot assume that our results are free from the influence of difference in training effects These differences would work to lower our correlations, it is true, but one would expect it to work within each group as well as between the groups

The question at once arises as to whether the terms 'concrete' and 'abstract' as applied to reasoning are not, after all, but terms signifying extremes of degrees and not differences of kind Granting that our tests in Group II involve a more definite perceptual consciousness, we must remember that perception consists in great part of centrally aroused processes. Consider now the subject who, working a formboard, looks over the blocks and sees them in their proper relations *in his mind* before trying them out Are his brain-processes fundamentally different from those involved when he thinks out a mathematical problem? Our own contention is that it is both pernicious and false to classify our reasoning processes as to abstract and concrete We believe that a finer analysis of the fundamental capacity involved would show that these types of reasoning are but extreme differences in degree of difficulty, involving the same essential process

If we should ingeniously select all kinds of reasoning problems it is likely that we could form a measuring scale of an order of increasing difficulty and having no gaps At the bottom of the scale, near the zero point, would lie simple formboard tests, while near the upper end of the scale would be the so-called abstract tests If this way of viewing reasoning capacity is sound, then most reasoning tests which pretend to be scaled are at fault, for most scales use tests in which just one level or small range of the fundamental capacity to reason is involved. We use the term 'level' merely in the sense of "within a given range of difficulty." Any test which may be solved by any wild trial-and-error process in action is not a good test of reasoning. Reasoning is a process of solving problems, but not all problem-solving is reasoning.

One further theoretical suggestion may be made. We might regard the capacity to solve problems at the upper end of the scale mentioned above (that is, solve what is now called abstract reasoning problems) as a higher form of evolutionary development than the capacity to solve problems at the lower end of the scale. Thus we should expect that those who can solve by reason problems that in our present terminology, are called abstract, could also reason well in concrete problems, although the reverse would not necessarily be true.[4]

## III

What is the relation between the amount of time taken and the number of changes made in working so-called concrete problems? The correlation between time taken and the number of changes made in constructing the formboards we found as follows:

In case of Healy Puzzle B, r is .891, P. E., .0228, N, 38 Men
In case of Dearborn Board, r is .630, P. E., .0670, N, 38 Men

In other words the time for solving this kind of situation, where trial and error are at a premium, can be largely substituted for the actual moves or changes made.

## IV

In a very stimulating piece of work reported by J. F. Shepard and H. M. Fogelsonger[5] a serious attempt was made to get at the fundamental thing involved in reasoning and attention by experimental methods These investigators say (page 310):

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[4] The writer has made these contentions before. See "Correlation between Healy Picture Completion Test and Terman Binet," *Journal of Educational Psychology*, 11 (1920): 418–421, and also Johnson, Burford, and Schriefer, "A Comparison of Mental Age Scores Obtained by Performance Tests and the Stanford Revision of the Binet Simon Scale," *op. cit.*, 13 (1922): 406–419.

What is badly needed is a keener analysis of the fundamental process or capacity involved in reasoning — the thing that makes reasoning reasoning. That is what we want to measure.

[5] "Studies in Association and Inhibition," *Psy. Rev.*, XX (1913): 290–311.

> it is desired merely to suggest here that the interassociations among the elements of a group have their inhibitory side of the kind shown in our experiments, which causes the factors of a sub-group to hold together and at the same time seem incomplete, which prevents mixture and confusion of groups and which consequently, in the alternation from one group to another, forces a distinction of the differences from the likenesses up to the limit of this type of ability for the individual

These writers attempt to reduce reasoning, in essence, to a capacity for noting likenesses and differences For them this capacity is the *sine qua non* of reasoning Others suggest the 'likeness side' Kuo[6] finds that this capacity to discover relationships, to discover the common elements involved, is the mark of the good reasoner We incorporated among our tests one for judging similarities and differences between triangles Reference to Tables I and II shows at a glance that there is practically no relationship between capacity in this test and the other reasoning tests The only suggestion derived from these facts is that when we say that the capacity to notice relationships, to note similarities and differences, or to pick out common elements is essential to reasoning, we probably must eliminate these processes as present in simple perceptual experience It is possible that an ingenious scale might be devised for measuring basic reasoning capacity which, according to the suggestions in the researches reported above, would be radically different from anything now existing under the name of reasoning test

## V

A brief comparison may be made between the scores of the men and women whose records contributed to Table I. In all cases, except the Healy Puzzle Construction test, the median for the men is better than that for the women and is likewise more variable The results are as follows:

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[6] "A Behavioristic Experiment on Inductive Inference," *Journ. Expt. Psy.*, VI (1923) 247-293

Thurstone Reasoning Test A
Median for men, 8, M V , 2 96, range, 3–18 inclusive, N, 62
Median for women, 7, M V , 2 93, range, 2–17 inclusive, N, 55

Thurstone Reasoning Test B
Median for men, 14, M V , 5 01, range, 3–28 inclusive, N, 63
Median for women, 12, M V , 4 79, range, 2–29 inclusive, N, 55

Number Plan Completion Test
Median for men, 12, M V , 2 73, range, 5–19 inclusive, N, 64
Median for women 11, M V , 1 94, range, 6–17 inclusive, N, 55

Arithmetic Reasoning Test
Median for men, 13, M V , 1 82, range, 7–19 inclusive, N, 64
Median for women, 11, M V , 1 72, range, 1–18 inclusive, N, 54

Healy Puzzle Construction Puzzle B
Median for men, 66 seconds, N, 52, range, 23–386 seconds
Median for women, 66 seconds, N, 47, range, 22–837 seconds

## SUMMARY

1 Following the popular common-sense classification we divided our tests into two groups, one called 'abstract' and the other 'concrete ' Within each group the intra-correlations were found positive and consistently high The correlation between the two groups, however, was very small in most cases and never high

2. The fact of positive, though low, correlation between the groups suggests that there is something common to any and all kinds of true reasoning

3 The fact that the correlations within each group were far higher than the correlations between the groups suggests that we are dealing either with two different things or capacities or else two extremes of the same thing

4. The suggestion is offered that it is both false and confusing to speak of concrete and abstract *types* of reasoning A keener analysis of the fundamental capacity or processes involved in each case would indicate that the same capacity is involved, any difference being merely one of degree and not of kind

5. So-called 'concrete' reasoning tests, such as are considered in this report, are poor tests because they permit of so much trial-and-error process, which may lead to a solution of the problem.

6 If we grant that reasoning is a unique form of association process in which a capacity to note likenesses and differences is fundamental, then this capacity in the form of perceptual discrimination must be ruled out Ability to note likeness and difference in perceptual discriminations, as such, is no indication whatever of capacity to reason

7 In so-called 'concrete' forms of reasoning tests (usually called 'performance' tests) the time taken, when the subject is told to work the problem as fast as possible, is a good indication of the number of moves or changes made

8 Among college students there is indication that the men do better on the more truly reasoning tests than the women The median of the men is also more variable

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# THE PROPORTION OF EXCEPTIONS IN THE OFFSPRING OF EXCEPTIONAL FEMALES FROM X-RAY TREATMENT OF DROSOPHILA*

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IRREGULARITY in the maturation divisions in females of *Drosophila melenogaster* gives rise to occasional eggs having two X-chromosomes or none in place of the single X-chromosome normally present These give rise to females or males which are exceptional in that they do not derive their sex-linked characters in the usual crisscross fashion (Bridges, 1916) The frequency of these primary non-disjunctional exceptions is about 1 per 4000 for females and about 1 per 1000 for males (Bridges, 1916, Safir, 1920, Mavor, 1922, 1923, 1924, Anderson, 1924) When females are subjected to X-ray treatment, there results an increased percentage of exceptions The percentage of exceptions after X-ray treatment is about twenty times as great as the percentage obtained without treatment (Mavor, 1922, 1923, 1924; Anderson, 1924)

When progenies are grown from the exceptional females, exceptional offspring are again obtained In this case they are due to the presence of a supernumerary Y-chromosome in the mother The proportion of these secondary exceptions is usually about four per cent for both sexes (Bridges, 1916) One line giving twenty per cent of exceptions was reported by Bridges (1916) and has been further studied also by Bonnier (1923) These investigators have shown that the potentiality of producing a high percentage of exceptions is transmitted through the X-chromosomes of this line

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* Paper from the Department of Botany of the University of Michigan, No 235, reporting research conducted by the author while holding appointment as National Research Fellow in Biology

In order to use X-rays as a help in determining the percentage of secondary non-disjunction characteristic of a given stock of Drosophila, it is essential that we know whether or not the X-ray treatment may cause any hereditary alteration of this characteristic The evidence available for Drosophila indicates only a temporary effect of the X-rays on the maturation divisions occurring within a limited period after treatment with no hereditary modifications in the chromosomes themselves (Mavor, *loc cit*, Mavor and Svenson, 1924) Thus we may expect the exceptional flies obtained after X-ray treatment to give the same distribution of offspring as the exceptions which occur naturally without X-ray treatment But experimental verification is important before the use of X-rays is justified as a method of determining the normal capacity of any stock to produce secondary exceptions in the presence of a supernumerary Y-chromosome During the course of studies on the interrelations of non-disjunction and crossing-over by the help of X-rays, data were obtained on the progeny of a number of the primary exceptions obtained in this way

## EXPERIMENTAL DATA

Echinus cut garnet (*ec ct g*) females were mated to scute crossveinless vermilion forked (*sc cv v f*) males. Virgin $F_1$ females were rayed within 28 hours after emergence and then mated to yellow scute crossveinless Bar (*y sc cv B*) or yellow forked Bar (*y f B*) males (Anderson, 1924) Exceptional daughters were distinguished by their full round eyes in contrast to the Bar eyes of the regular daughters. The exceptional females obtained were mated to yellow scute crossveinless Bar males primarily in order to determine their X-constitutions As complete counts were made these progenies give the percentage of exceptions and also the distribution of crossovers among the males.

## TABLE I

### Progeny of Non-Equational Exceptions from X-Ray Treatment

| Exception number | Regular females | Regular males | Exceptional females | Exceptional males | Total | Percentage of exceptions |
|---|---|---|---|---|---|---|
| 3 | 398 | 384 | 9 | 11 | 802 | 2 5 |
| 4 | 299 | 248 | 11 | 7 | 565 | 3 2 |
| 12 | 73 | 78 | 1 | 2 | 154 | 1 9 |
| 14 | 245 | 135 | 7 | 16 | 403 | 5 7 |
| 25 | 180 | 168 | 5 | 4 | 357 | 2 5 |
| 26 | 206 | 183 | 4 | 9 | 402 | 3 2 |
| 27 | 186 | 170 | 7 | 4 | 367 | 3 0 |
| 28 | 240 | 234 | 6 | 10 | 490 | 3 3 |
| 30 | 244 | 252 | 6 | 6 | 508 | 2 4 |
| 32 | 151 | 128 | 3 | 2 | 284 | 1 8 |
| 35 | 294 | 295 | 8 | 12 | 609 | 3 3 |
| 37 | 141 | 135 | 5 | 3 | 284 | 2 8 |
| 39 | 160 | 152 | 3 | 2 | 317 | 1 6 |
| 42 | 123 | 117 | 3 | 3 | 246 | 2 4 |
| 43 | 70 | 66 | 2 | 3 | 141 | 3 5 |
| 47 | 135 | 138 | 4 | 6 | 283 | 3 5 |
| 51 | 125 | 108 | 0 | 1 | 234 | 0 4 |
| 57 | 106 | 101 | 1 | 5 | 213 | 2 8 |
| 62 | 158 | 139 | 10 | 5 | 312 | 4 8 |
| 63 | 202 | 194 | 5 | 4 | 405 | 2 2 |
| 65 | 258 | 246 | 3 | 12 | 519 | 2 9 |
| 68 | 107 | 96 | 5 | 6 | 214 | 5 1 |
| 73 | 109 | 112 | 4 | 5 | 230 | 3 9 |
| 75 | 68 | 37 | 2 | 1 | 108 | 2 8 |
| 98 | 90 | 69 | 3 | 2 | 164 | 3 0 |
| 102 | 95 | 85 | 3 | 2 | 185 | 2 7 |
| 109 | 184 | 203 | 2 | 3 | 392 | 1 3 |
| 112 | 850 | 761 | 21 | 30 | 1662 | 3 1 |
| 129 | 166 | 121 | 5 | 8 | 300 | 4 3 |
| 133 | 93 | 86 | 5 | 2 | 186 | 3 8 |
| 135 | 74 | 63 | 2 | 2 | 141 | 2 8 |
| 136 | 57 | 54 | 6 | 0 | 117 | 5 1 |
| 140 | 125 | 119 | 2 | 3 | 249 | 2 0 |
| 142 | 139 | 108 | 7 | 2 | 256 | 3 5 |
| 144 | 89 | 88 | 3 | 4 | 184 | 4 3 |
| 146 | 129 | 103 | 4 | 1 | 237 | 2 1 |
| 157 | 81 | 64 | 0 | 0 | 145 | 0 0 |
| 17 | 326 | 318 | 9 | 7 | 660 | 2 4 |
| 19 | 194 | 177 | 3 | 3 | 377 | 1 6 |
| 128 | 105 | 117 | 6 | 3 | 231 | 3 9 |
| 5 | 239 | 210 | 3 | 5 | 457 | 1 8 |
| 130 | 99 | 91 | 2 | 1 | 193 | 1 6 |
| 59 | 203 | 164 | 4 | 7 | 378 | 2 9 |
| 127 | 115 | 122 | 2 | 5 | 244 | 2 9 |
| 137 | 79 | 69 | 2 | 3 | 153 | 3 3 |
| 34 | 200 | 208 | 11 | 10 | 429 | 4 9 |
| Total | 8010 | 7316 | 219 | 242 | 15787 | 2 9 |

Table I gives the numbers of regular and exceptional offspring for the non-equational exceptions, i e. those which retained the entire X-constitution of their mother The last nine cultures were from females whose X-chromosomes were complementary crossovers Many of the lines were carried along several generations by breeding from exceptional daughters, the data from all cultures being combined Progenies from forty-six primary exceptions are listed The frequencies of secondary exceptions range from 0 to 6 per cent with a mean of 2 9 per cent These percentages are distributed as follows

| Percentages | Frequency |
|---|---|
| 0 to 1 | 2 |
| 1 to 2 | 7 |
| 2 to 3 | 17 |
| 3 to 4 | 13 |
| 4 to 5 | 4 |
| 5 to 6 | 3 |

The distribution approximates a normal frequency curve as is expected of random variations The departures from the mean (2 9 per cent) or from 4 per cent are not greater than may be accounted for by errors of sampling alone If any heritable differences exist, they are of minor importance only, or act in the direction of reducing the percentage of exceptions

Table II gives the crossing-over from the same cultures Only the males could be used, and in general, these were classified for the first culture only. Thus the numbers involved are much smaller than those of Table I. A summary of the crossing-over data from Table II is given in Table III. Table IV gives a similar summary of crossing-over from control cultures. The female parents of these cultures were of the same constitution as those subjected to X-ray treatment. For comparison the standard map values as given by Bridges (1920) are added The crossover data appear to be reasonably homogeneous.

## TABLE II

MALE PROGENY OF NON-EQUATIONAL EXCEPTIONS FROM X-RAY TREATMENT CLASSIFIED ACCORDING TO CROSSING-OVER

| Exception number | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 1, 3 | 1, 4 | 1, 5 | 1, 6 | 2, 3 | 2, 4 | 2, 5 | 2, 6 | 3, 4 | 3, 5 | 3, 6 | 4, 5 | 4, 6 | 5, 6 | 1, 4, 6 | 2, 4, 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 37 | 4 | 6 | 0 | 10 | 5 | 11 |  |  |  |  |  |  |  |  |  |  | 2 | 2 |  | 1 |  |  |
| 4 | 28 | 2 | 4 | 5 | 10 | 7 | 5 |  |  | 2 |  |  |  | 1 | 1 |  |  |  |  | 2 |  |  |  |
| 12 | 31 | 1 | 6 | 4 | 11 | 6 | 8 |  | 1 |  |  |  |  |  | 1 |  | 1 |  |  |  |  |  |  |
| 14 | 30 | 5 | 5 | 7 | 7 | 4 | 6 |  | 1 | 1 | 1 |  |  |  | 2 |  | 1 |  |  |  |  |  |  |
| 25 | 44 | 2 | 4 | 8 | 8 | 7 | 5 |  |  |  |  |  | 1 |  | 1 |  |  |  |  | 4 |  |  |  |
| 26 | 49 | 1 | 7 | 8 | 16 | 9 | 3 |  | 1 | 2 | 3 |  |  | 1 |  |  |  | 2 |  | 1 |  |  |  |
| 27 | 50 | 3 | 4 | 6 | 11 | 9 | 8 |  | 2 | 2 |  |  |  | 2 | 1 |  | 1 | 3 |  |  |  |  |  |
| 28 | 48 | 2 | 10 | 8 | 14 | 3 | 5 |  |  | 1 |  |  |  | 2 | 1 | 1 | 1 | 2 | 2 | 2 |  |  |  |
| 30 | 54 | 11 | 15 | 8 | 15 | 8 | 13 |  |  |  | 1 |  |  | 2 |  |  | 2 |  |  | 1 |  | 1 | 1 |
| 32 | 15 | 6 | 4 | 1 | 9 | 5 | 4 | 1 |  | 2 | 1 |  |  |  | 1 |  |  |  |  |  |  |  |  |
| 35 | 39 | 5 | 2 | 8 | 13 | 2 | 3 |  |  |  | 1 |  |  |  |  |  |  |  |  | 1 |  |  |  |
| 37 | 37 | 2 | 5 | 6 | 6 | 11 | 6 |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |
| 39 | 24 | 1 | 3 | 8 | 6 | 6 | 1 |  |  |  | 1 |  | 1 | 1 |  |  | 2 |  |  | 2 |  |  |  |
| 42 | 36 | 4 | 3 | 5 | 11 | 5 | 3 |  | 1 | 1 |  |  |  |  | 1 |  |  | 1 | 1 |  |  |  |  |
| 43 | 30 | 2 | 5 | 5 | 8 | 8 | 7 |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |
| 47 | 53 | 1 | 6 | 12 | 16 | 13 | 4 |  | 1 |  |  |  | 2 | 1 | 1 |  |  | 2 |  | 1 |  |  |  |
| 51 | 35 | 2 | 9 | 6 | 8 | 7 | 4 |  | 1 | 2 |  |  | 2 | 1 | 2 |  | 1 |  |  | 1 |  |  |  |
| 57 | 44 | 6 | 10 | 6 | 14 | 9 | 3 |  |  | 2 | 1 |  |  |  | 1 |  | 1 | 2 |  | 2 |  |  |  |
| 62 | 41 | 4 | 6 | 2 | 14 | 2 | 5 |  |  |  |  |  | 1 | 2 | 1 |  |  | 1 |  | 1 | 1 |  |  |
| 63 | 48 | 4 | 8 | 6 | 14 | 11 | 2 |  | 1 |  | 2 |  |  | 5 | 1 |  | 1 |  |  | 1 |  |  |  |
| 65 | 48 | 4 | 8 | 4 | 13 | 10 | 8 |  |  |  | 1 |  |  | 1 |  |  | 1 | 1 |  | 1 |  |  |  |
| 68 | 43 | 4 | 7 | 7 | 13 | 9 | 4 |  | 2 | 1 |  |  |  | 2 | 1 |  | 1 | 2 |  |  |  |  |  |
| 73 | 51 | 7 | 8 | 11 | 17 | 8 | 3 |  | 1 | 1 |  | 1 | 2 | 1 | 1 |  | 1 |  |  |  |  |  |  |
| 75 | 13 | 1 | 4 | 1 | 11 | 3 | 2 |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |

## TABLE II—*Continued*

Male Progeny of Non-Equational Exceptions from X-Ray Treatment Classified according to Crossing-over

| Exception number | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 1, 3 | 1, 4 | 1, 5 | 1, 6 | 2, 3 | 2, 4 | 2, 5 | 2, 6 | 3, 4 | 3, 5 | 3, 6 | 4, 5 | 4, 6 | 5, 6 | 1, 4, 6 | 2, 4, 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 97 | 41 | 4 | 8 | 7 | 17 | 7 | 8 |  | 1 |  |  |  |  |  | 2 |  | 3 |  |  | 1 |  |  | 1 |
| 98 | 33 | 3 | 5 | 4 | 11 | 2 | 5 |  | 1 | 1 | 2 |  |  |  |  | 1 |  |  |  | 1 |  |  |  |
| 102 | 38 | 6 | 3 | 6 | 9 | 6 | 8 |  |  | 1 | 1 |  |  | 3 |  |  | 2 |  |  | 2 |  |  |  |
| 103 | 26 | 3 | 3 | 6 | 9 | 7 | 3 |  |  |  | 1 |  | 2 |  | 1 |  |  |  |  |  |  |  |  |
| 109 | 35 | 6 | 9 | 6 | 6 | 5 | 9 |  | 1 | 1 | 2 |  | 1 | 1 | 1 |  | 2 |  |  |  |  |  |  |
| 112 | 50 | 7 | 4 | 5 | 14 | 16 | 8 |  | 1 |  | 1 |  |  | 2 |  |  |  |  | 3 |  |  |  |  |
| 133 | 42 | 4 | 6 | 5 | 6 | 8 | 3 |  | 3 | 1 | 1 |  | 2 | 1 | 3 |  |  |  |  | 1 |  |  |  |
| 135 | 28 | 5 | 8 | 4 | 6 | 5 | 6 |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |
| 136 | 23 | 3 | 3 | 6 | 5 | 5 | 6 |  |  |  |  |  |  | 1 | 1 |  |  |  |  |  | 1 |  |  |
| 140 | 65 | 4 | 7 | 6 | 11 | 5 | 5 |  |  | 3 | 1 |  | 1 |  |  |  | 1 | 3 | 3 | 1 | 2 |  | 1 |
| 142 | 47 | 2 | 7 | 9 | 12 | 9 | 13 |  |  |  | 3 |  |  | 1 | 3 |  | 1 |  |  | 1 |  |  |  |
| 144 | 44 | 3 | 3 | 7 | 7 | 15 | 5 |  |  |  |  |  |  |  | 2 | 1 |  | 1 |  |  |  |  |  |
| 146 | 52 | 7 | 8 | 5 | 12 | 8 | 5 |  |  |  |  |  |  | 2 | 2 |  | 1 |  | 1 |  |  |  |  |
| 157 | 26 | 3 | 3 | 5 | 6 | 6 | 7 |  |  |  | 1 |  |  |  | 3 |  | 2 | 1 |  | 1 |  |  |  |
| 17 | 55 | 2 | 16 | 7 | 10 | 11 | 6 |  |  |  |  |  |  | 1 | 1 |  | 1 |  |  | 2 |  |  |  |
| 19 | 30 | 2 | 6 | 9 | 13 | 11 | 7 |  |  | 2 | 1 |  | 1 | 2 |  | 1 | 2 | 1 |  | 2 | 1 |  |  |
| 128 | 64 | 3 | 6 | 2 | 17 | 8 | 4 |  | 1 | 3 |  |  | 1 | 2 | 1 | 1 | 1 |  |  | 3 |  |  |  |
| 5 | 18 | 1 | 3 | 0 | 6 | 6 | 8 |  | 2 |  |  |  | 2 | 1 |  |  |  |  | 2 | 1 |  |  |  |
| 130 | 43 | 5 | 5 | 3 | 12 | 10 | 5 |  | 1 | 4 |  |  |  | 1 | 1 |  |  |  |  | 1 |  |  |  |
| 59 | 64 | 2 | 10 | 7 | 13 | 9 | 15 |  |  | 1 | 2 |  |  |  | 1 |  |  | 1 |  | 1 | 1 |  |  |
| 127 | 48 | 4 | 8 | 9 | 12 | 16 | 13 |  |  | 3 | 1 |  |  | 1 | 1 |  | 1 |  | 1 | 2 | 2 |  |  |
| 137 | 39 | 1 | 3 | 1 | 9 | 7 | 2 |  | 1 | 1 |  |  | 1 | 2 |  |  |  |  | 1 | 1 |  |  |  |
| 34 | 46 | 3 | 4 | 2 | 6 | 4 | 6 |  |  |  |  |  |  |  | 2 |  | 2 |  |  | 1 |  |  |  |
| Total | 1885 | 167 | 287 | 263 | 504 | 353 | 280 | 1 | 24 | 38 | 29 | 1 | 20 | 43 | 45 | 5 | 34 | 25 | 16 | 42 | 9 | 1 | 3 |

## TABLE III

### Summary of Male Progeny of Non-Equational Exceptions

| Crossover region | Frequency | Total crossovers | Percentage | Coincidence |
|---|---|---|---|---|
| 0 | 1885 | | 46.3 | |
| 1 sc–ec | 167 | 260 | 6.4 | |
| 2 ec–cv | 287 | 399 | 9.8 | |
| 3 cv–ct | 263 | 329 | 8.1 | |
| 4 ct–v | 504 | 615 | 15.1 | |
| 5 v–g | 353 | 393 | 9.6 | |
| 6 g–f | 280 | 434 | 10.6 | |
| 1, 2 | 0 | | | .00 |
| 1, 3 | 1 | | | .05 |
| 1, 4 | 24 | | | .64 |
| 1, 5 | 38 | | | 1.51 |
| 1, 6 | 29 | | | 1.05 |
| 2, 3 | 1 | | | .03 |
| 2, 4 | 20 | | | .37 |
| 2, 5 | 43 | | | 1.12 |
| 2, 6 | 45 | | | 1.06 |
| 3, 4 | 5 | | | .10 |
| 3, 5 | 34 | | | 1.07 |
| 3, 6 | 25 | | | .71 |
| 4, 5 | 16 | | | .27 |
| 4, 6 | 42 | | | .70 |
| 5, 6 | 9 | | | .22 |
| 1, 4, 6 | 1 | | | |
| 2, 4, 6 | 3 | | | |
| Total | 4075 | | | |

## TABLE IV

SUMMARY OF MALE PROGENY OF CONTROL FEMALES

| Crossover region | Frequency | Total crossovers | Percentage | Coincidence | Standard |
|---|---|---|---|---|---|
| 0 | 924 | | 45 1 | | |
| 1 sc–ec | 103 | 152 | 7 4 | | 5 5 |
| 2 ec–cv | 151 | 213 | 10 4 | | 8 2 |
| 3 cv–ct | 140 | 171 | 8 4 | | 7 3 |
| 4 ct–v | 221 | 286 | 14 0 | | 13 0 |
| 5 v–g | 179 | 239 | 11 7 | | 11 4 |
| 6 g–f | 157 | 238 | 11 6 | | 12 1 |
| 1, 2 | 0 | | | 00 | |
| 1, 3 | 1 | | | 08 | |
| 1, 4 | 16 | | | 80 | |
| 1, 5 | 17 | | | 96 | |
| 1, 6 | 14 | | | 79 | |
| 2, 3 | 1 | | | 06 | |
| 2, 4 | 13 | | | 50 | |
| 2, 5 | 21 | | | 84 | |
| 2, 6 | 25 | | | 1 01 | |
| 3, 4 | 4 | | | 17 | |
| 3, 5 | 12 | | | 65 | |
| 3, 6 | 12 | | | 60 | |
| 4, 5 | 6 | | | 18 | |
| 4, 6 | 23 | | | 78 | |
| 5, 6 | 3 | | | 14 | |
| 1, 4, 6 | 1 | | | | |
| 2, 4, 6 | 2 | | | | |
| 3, 5, 6 | 1 | | | | |
| Total males | 2047 | | | | |
| Females | 2014 | | | | |

## TABLE V

### PROGENY OF EQUATIONAL EXCEPTIONS FROM X-RAY TREATMENT

| Exception number | Phenotype | Regular females | Regular males | Exceptional females | Exceptional males | Total | Percentage of exceptions |
|---|---|---|---|---|---|---|---|
| 1 | sc cv | 362 | 388 | 15 | 18 | 783 | 4.2 |
| 2 | + | 229 | 221 | 4 | 8 | 462 | 2.6 |
| 10 | sc | 139 | 147 | 0 | 2 | 288 | 0.7 |
| 18 | sc cv | 258 | 264 | 6 | 4 | 532 | 1.9 |
| 22 | + | 203 | 176 | 13 | 11 | 403 | 6.0 |
| 24 | ec ct | 219 | 192 | 6 | 7 | 434 | 3.0 |
| 54 | v f | 157 | 108 | 3 | 6 | 274 | 3.3 |
| 58 | sc cv v | 102 | 81 | 6 | 4 | 193 | 5.2 |
| 61 | sc | 112 | 142 | 3 | 2 | 302 | 1.7 |
| 71 * | + | 131 | 67 | 3 | 2 |  | 1.9 |
| 72 | + | 143 | 125 | 0 | 2 | 270 | 0.7 |
| 74 * | + | 135 | 58 | 4 | 0 |  | 1.6 |
| 91 | cv v f | 115 | 109 | 2 | 7 | 233 | 3.9 |
| 117 | sc cv v | 127 | 89 | 1 | 0 | 217 | 0.5 |
| 139 | + | 118 | 127 | 2 | 1 | 248 | 1.2 |
| 147 | ec ct | 94 | 90 | 5 | 5 | 194 | 5.2 |
| 149 | f | 108 | 96 | 4 | 2 | 210 | 2.9 |
| 20 | ec | 138 | 106 | 24 | 16 | 284 | 14.1 |
| 80 | v | 1604 | 1541 | 654 | 551 | 4350 | 27.7 |

* A sex-linked lethal present killing one half of the regular males

Nineteen equational exceptions from the X-ray treatment were tested in the same way. The data on secondary non-disjunction are given in Table V. Seventeen of these gave percentages ranging from 0.5 to 6 per cent. The variability is somewhat greater than that shown in Table I, but the percentages are all reasonably near the normal or usual ones. The percentages of crossing-over were also as near normal as could be expected for the low numbers involved.

The two remaining lines gave much higher percentages of secondary exceptions. One of these, No. 20, gave forty exceptions out of a total of 284, or 14.1 per cent. The deviation from 4 per cent is about ten times the probable error, and is certainly significant. Only fifty-one males were classified for crossing-over. These were distributed as follows.

| | Frequency | Approximate expectation |
|---|---|---|
| Non crossovers | 43 | 29 |
| Crossovers *cv-ct* | 5 | 4 |
| *ct-v* | 3 | 7 |
| *v-g* | 0 | 5 |
| *g-f* | 0 | 6 |
| Total | 51 | 51 |

The chances are only about 1 in 2000 that the deviations are due to errors of sampling (P = .0005). The X-constitution of exception No. 20 was $\frac{sc\quad ct\ v\quad f}{sc\ cv\quad g}$ which may be represented schematically as $\frac{b\ b\ b\ b\ a\ a\ a}{b\ b\ a\ a\ b\ b\ b}$. Owing to the pressure of other work, no effort was made to save this line beyond a few generations. The other line, No. 80, gave still more divergent results and has been continued. The X-constitution of exception No. 80 was $\frac{sc\quad cv\ v\quad f}{sc\quad v\ g}$, which may be represented schematically as $\frac{a\ a\ a\ a\ a\ a\ a}{b\ b\ b\ a\ a\ b\ b}$. The exceptional offspring in this line amount to about 27 per cent. Crossing-over is apparently normal from scute to crossveinless, but is much reduced between crossveinless and forked This high non-disjunction line is being studied and will be reported separately

## SUMMARY

Forty six non-equational exceptions from X-ray treatment were tested. All gave the usual low percentages of exceptions and normal crossing-over. Of nineteen equational exceptions tested, seventeen gave normal percentages of exceptions and normal crossing-over, while two gave high percentages of exceptions and reduced crossing-over in the right-hand (*v g f*) portion of the X-chromosome.

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# A COLLECTION OF AMPHIBIANS AND REPTILES FROM SOUTHERN INDIANA AND ADJACENT KENTUCKY*

FRANK N BLANCHARD

IN June, 1924, the writer went to southern Indiana to collect amphibians and reptiles The greater part of the collecting was done in Brown, Lawrence and Vanderburg counties, Indiana, and in Henderson County, Kentucky

Local lists that give specific information have so often proved of decided value to the writer that he has no hesitancy in offering the present account of the results of this trip All the specimens collected have been deposited in the Museum of Zoology of the University of Michigan, and their numbers are given in parentheses in the text

AMBYSTOMA MICROSTOMUM Cope — An adult (60973) and a small one with the stub of the gills still showing (60974) were taken under logs in a wet woods near Smith Mills, Henderson County, Kentucky, June 15. The next day three adults and eight recently transformed young ones (60975) were taken in the same woods. Four of the latter were brought to Ann Arbor and kept alive for many weeks, feeding readily on earthworms They showed a strong propensity for keeping concealed. On June 10, larvae were found in abundance in pools at the side of a road through woods in Union Township, Vanderburg County, Indiana, and in small pools in the same woods. This woods is on the flood-plain of the Ohio River and is under water in the spring Newly transformed individuals were common here under logs and chunks of wood. A series of forty-eight individuals with gills was seined from the pools and fifteen were found out of water under wood with their gills in various stages of reduction (60976).

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* Contribution from the Zoölogical Laboratory of the University of Michigan

No adults were found here  Three transforming individuals (60977) were taken two days later in Perry Township, in the same county, in a wet woods at the edge of the Ohio River flood-plain

AMBYSTOMA OPACUM (Gravenhorst) — One adult (60971) with short regenerated tail was taken from under a small log in deep woods, Perry Township, Vanderburg County, Indiana, June 12, and another adult (60972), with no tail whatever, but the stump healed, was found under a piece of old burlap in wet woods, Henderson County, Kentucky, June 15

PLETHODON CINEREUS DORSALIS Cope — Eight specimens (60989) were taken under leaves and logs in a small, damp, wooded ravine near the flood-plain of the Ohio River in Henderson County, Kentucky, June 15  In three of these the lobulated dorsal band is distinct, although inconspicuous, in four of them it is barely discernible or indistinguishable, the dorsal band in one is inconspicuous, and not lobulated, and is continuous to the tip of the tail  On the tip of the snout of each specimen is a light spot, which in some cases extends ventrally, forming a vertical bar  This spot is continued for a varying distance posteriorly along the canthus rostralis on each side  There are from 15 to 16 complete costal grooves, exclusive of the one directly over the front leg and the incomplete one in front of the hind leg. Following are the measurements in millimeters and the numbers of grooves  The body length is measured from the tip of the snout to the posterior insertion of the hind leg and the tail is measured from that point to its tip.

| Body length | Tail length | Costal grooves |
|---|---|---|
| 29 | 25 | 16 |
| 24 | 22 | 16 |
| 25 | 23 | 16 |
| 25 | 26 | 15 |
| 24.8 | 24 8 | 16 |
| 25 | | 15 |
| 25 8 | 25 | 16 |
| 23 5 | | 16 |

From 2 miles west of Nashville, Brown County, Indiana, June 5, a specimen (60990) with broad lobulated band on the body, continuing with parallel outlines on the tail, was taken with a number of other specimens mostly patterned like *P. cinereus* This individual has a broad vertical rostral bar extending down to the lip and backwards, faintly, along the canthi There are 16 complete costal grooves The body is 33 mm long and the tail 34 mm. Another specimen from the same collection (60991) has 15 complete costal grooves, a faintly marked rostral bar, and a rather faint lobulated dorsal band on the anterior half of the body This band is continued with parallel sides on the posterior part of the body and indistinctly on the tail Thus this specimen combines the patterns of *P. dorsalis* and *P. cinereus* Its body is 37 mm long, its tail is incomplete.

Plethodon cinereus cinereus (Green) — With the two specimens of *P dorsalis* (60990–91) collected 2 miles west of Nashville, Indiana, were taken five specimens (60992) patterned like *P. cinereus*. Four of these show broad, parallel-sided dorsal bands, with more or less dusky mottling, and one is without a dorsal band. The latter has 16 complete costal grooves and the other four have each 17 The rostral bar is missing in every case. The body lengths are 39, 32, 38, 37 and 22 5 millimeters, and the tail lengths of the first three are 41, 35 and 41, respectively The last two have incomplete tails.

Two specimens (60993–94) with the pattern of *P. cinereus* were taken 7 miles west of Columbus, Indiana, June 21 The first of these has 17 complete costal grooves, the second, 16 Their body lengths are 25 and 26 mm and their tail lengths 25.3 and 24.3 mm, respectively.

A series of five specimens (60995) was collected 8 miles east of Nashville, Indiana, June 4. None of these show the rostral bar of *P. dorsalis*. One has a body length of 41 mm. and a tail length of 52 mm, and 16 complete costal grooves The dorsal stripe is interrupted with dusky mottling on the forward part of the body and disappears on the anterior part of the tail. The other specimens are juveniles of apparently the second season. Three of these have brilliant stripes on body and tail, and one has no stripe One of the first three of these has 16 complete costal grooves, the rest of the collection all have 17

From a study of Dunn's excellent delineations of *P. dorsalis* and *P. cinereus* (1918, p 460), it appears that the specimens collected in Henderson County, Kentucky, are typical of *P dorsalis*, while those collected in Brown County, Indiana, are partly *P dorsalis*, partly *P cinereus*, and partly intermediate between these forms It seems that there can be little question that we have here two geographic races or subspecies Cope (1889, p 139) might not have been in doubt on this point if his material had been more accurately labeled and had definitely included specimens from such an intermediate region as south-central Indiana

PLETHODON GLUTINOSUS (Green) — This species was found to be common in several localities. Eight (60963) of varying sizes were collected under loose bark of fallen logs in deep woods, and in soft earth under logs, in Perry Township, Vanderburg County, Indiana, June 12, seven (60964) were taken in woods near Smith Mills, Henderson County, Kentucky, June 15, one (60965) was taken 2 miles west of Nashville, Indiana, June 5, one (60966) was collected 7 miles west of Columbus, Indiana, June 21, two (60967–68) were found in the woods by Donaldson's Cave, Mitchell, Indiana, June 6, and two (60969-70) were taken 8 miles east of Nashville, June 4.

EURYCEA BISLINEATA BISLINEATA (Green) — One adult (60934) was taken in the stream below Donaldson's Cave, Mitchell, Indiana, June 19, 1924, and two in a small stream about 7 miles west of Columbus, Brown County, Indiana, June 21.

EURYCEA LUCIFUGA Rafinesque — Two adults (60926–27) were taken in Twin Caves, near Mitchell, Indiana, June 18, and four more the next day (60928–31) Also on June 19 two adults (60932–33) were found in Donaldson's Cave, near by These salamanders were found in every case within the region of dim light, not in the absolute darkness far from the entrance. They were among the stones near the flowing water, or on the earth next to the side wall of rock, or on a ledge, or in a crevice of the side wall. They showed no disposition to avoid the flashlight One individual was brought alive to Ann Arbor where it was kept in a covered glass dish for fourteen months In the dish were put numerous stones, and enough water to make the place wet This individual fed readily on fruit flies, but was kept alive for the most part on a diet of earthworms Sometimes it struck first at an earthworm with its tongue, but usually, as does an Ambystoma, it seized it immediately with its jaws

BUFO FOWLERI Garman — One specimen (60937) was taken at the entrance to Twin Caves, Mitchell, Indiana, on June 18, and on the next day one was taken near Donaldson's Cave (60945). No species of Bufo is mentioned in Hahn's report on this region Four singing males (60938–41) were collected in and near a shallow pool within the city limits of Evansville, on the evening of June 11 Two (60942–43) were taken in a woods clearing in Perry Township, Vanderburg County, Indiana, June 12 Ten singing males and two females (60944) were collected in a shallow river about 10 miles west of Columbus, Indiana, just after dark on June 20

ACRIS GRYLLUS (Le Conte) — Two were found on the moist woods path leading down to Donaldson's Cave, Mitchell, Indiana, June 6, and one was found in the clearing by the cabin (60961)

PSEUDACRIS TRISERIATA (Wied) — Three adults (60958) were taken in a heavy swamp woods near Smith Mills, Henderson County, Kentucky, on June 15, and five more adults (60958), and six recently transformed juveniles (60960) were taken in the same woods the next day. In two individuals the heel extending forward reaches the anterior portion of the tympanum, and in all the others the heel extends to the middle or anterior edge of the eye In four individuals the three longitudinal markings on the back are fairly well defined; in the others only small spots are discernible on the back

HYLA VERSICOLOR VERSICOLOR (Le Conte) — An adult (60962) was found on an oak tree, six feet from the ground, near Twin Caves, Mitchell, Indiana, June 20

RANA CATESBEIANA Shaw. — An adult female (61061) was taken in a sluggish stream near Smith Mills, Henderson County, Kentucky, June 16

Rana clamitans Latreille — A moderate-sized individual (60952) was taken near the stream from Donaldson's Cave, Mitchell, Indiana, June 6 Several more were seen A large one (60951) was taken in wet woods in Marrs Township, Posey County, Indiana, June 13

Rana palustris Le Conte — An adult (60953) was found in the woods near Donaldson's Cave, Mitchell, Indiana, June 6, and on June 18 another (60954) was found at the entrance to Hamer Cave, near by This species was not found by Hahn

Rana sphenocephala Cope — All the leopard frogs collected are referred to this species rather than to *R pipiens* because they look more like the southern than the northern leopard frogs They are very different in appearance from the leopard frogs of Michigan. The spots on the back are very small and are without light outlines. The head averages a little longer than in leopard frogs from Michigan, its length being contained in the total length two and one-half to three times The probability is that *R sphenocephala* intergrades with *R pipiens* somewhere north of southern Indiana

This species was abundant in the wet woods near Smith Mills, Henderson County, Kentucky Here a series of fifteen adults (60955) was collected June 16 These are all variously spotted on the upper surface of the body except one individual which is devoid of spots here, although its legs are patterned in the usual way A series of nine adults (60956) was taken on the flood-plain of the Ohio River, in Union Township, Vanderburg County, Indiana, June 10. Most of this flat land near Evansville is cleared and farmed, but a few small patches of woods remain, perhaps too wet to cultivate. These woods shelter many leopard frogs They were readily caught from under logs and rotten wood in the woods At the side of the road they were common in the grass, but were too lively to be easily caught Four specimens (60957) were taken at Mumford Hills, Bethel Township, Posey County, Indiana, June 14

Rana sylvatica Le Conte. — An adult (60946) was taken in the woods along Pigeon Creek, Ohio Township, Warrick County, Indiana, June 11, and two immature individuals (60947–48) were found the next day in heavy woods in Perry Township, Vanderburg County, Indiana. One (60950) was taken in heavy swamp woods near Smith Mills, Henderson County, Kentucky, June 16

SCELOPORUS UNDULATUS (Latreille). — A moderate-sized specimen (60999) was collected on an oak tree near Twin Caves, Mitchell, Indiana, June 20

EUMECES FASCIATUS (Linné). — A juvenile (60996) was taken about 5 miles east of Bloomington, Indiana, June 5, and two small ones (60997–98) were collected from under the bark of a log over a small stream in heavy woods in Perry Township, Vanderburg County, Indiana, June 12

CARPHOPHIS AMOENA HELENAE (Kennicott) — Two worm snakes (61022–23) were taken from under the loose bark of fallen logs in deep woods in Perry Township, Vanderburg County, Indiana, June 12, and on the next day a juvenile (61021) was found in the same woods in the wheel rut of a shaded road One (61017) was found on June 5 in a pile of small pieces of boards in a little clearing in woods a few miles east of Bloomington, Indiana On June 6, three (61018–20) were taken under the loose bark of a large fallen log in the woods just above Donaldson's Cave, Mitchell, Indiana On the 19th, search in the same woods brought to light nine more specimens (61024–32) These were all found under the loose bark of fallen logs. Three were taken together in one instance, and two in another.

The last nine specimens mentioned were all carried alive to Ann Arbor Two males were then preserved, and the other two males with the five females were cared for during the summer by Dr. Frieda Cobb Blanchard, to whom is due the credit for the following observations on habits and egg-laying.

### LAYING AND HATCHING OF EGGS OF CARPHOPHIS

There was considerable difference in the dispositions of these seven animals. The males were more easily frightened and much harder to feed than the females. Female No. 61027 was much tamer than the other females, and became at once a pet. Whenever any one of the females could be shown an earthworm without being disturbed first, it would eat it at once During the day, at least, they were always hidden under a piece of wood or in the loose earth This had to be carefully lifted away in order to feed them But No 61027 frequently rested with her head exposed, all ready for food, and when the dish was opened she came further out of cover, watching for something to eat On occasions when she was completely covered she could be brought out to look for her food by touching her anywhere on her body while one was poking about through the earth in search of her This operation would so frighten any one of the others that it would not eat

They all ate earthworms voraciously — usually two worms at a meal if of the largest size that they could manage, and more if smaller At times they were fed earthworms almost daily. The tamest specimen refused a tiny toad, of such a size that she could have eaten it Ants and ant pupae, from a nest in a decayed log, were put into all of the cages, but there was no indication that any were eaten

They were frequently seen to drink Several took long drinks while held in the hand, when they had not had access to water for several days

When these snakes are allowed to twine about the fingers the very sharp point on the end of the tail is pressed into the hand with considerable force, and the head is poked vigorously into crevices between fingers, and even into the soft palm of the hand, in evident attempt at concealment

Four of the five females laid their eggs early in July. The fifth, although almost as large as the smallest of these four, laid no eggs this season, and dissection in the autumn showed only very small eggs in the ovaries

The snakes were kept in closed glass dishes, containing, to the depth of one or two inches, a layer of decayed and disintegrated wood, and some small pieces of a well rotted log The moisture content of this material was the same as in the natural environment of these snakes It was kept constant by the glass cover, and no water was added This condition was maintained throughout the period of egg-laying and incubation.

The first clutch of eggs, two in number (from female No 61027), was found at 10 00 o'clock in the morning of July 7 These eggs were pretty certainly not present at 4 00 P M on July 6, and quite certainly were not there three days previous to discovery They were found barely covered in the loose soil, but had already been disturbed before they were noticed They were measured immediately

On July 11, eggs were found in the dishes of three of the other four females These were laid at some time between late in the day of July 7 and noon of July 11. Two of the clutches consisted of two eggs each and one of five The eggs of the first two clutches were immediately measured (61028, 61031) The clutch of five (61030) was left undisturbed until after a photograph had been taken (Pl XXII, Fig 3), and was then measured. Two of the parents (61031 and 61027) were allowed to remain with their eggs, and the other two were removed to other dishes in order to leave the eggs undisturbed in the position in which they were found.

The two eggs of female No 61028 were in a relatively large cavity, about 7 by 4 centimeters, in rotted and disintegrated wood — almost earth — with a piece of old wood forming the top The eggs were resting in a horizontal position practically on the glass bottom of the dish They were cream-colored with a decided lemon-yellow at the ends, the latter color extending over as much as would be seen from an end view One end was a little smaller and more pointed than the other (Fig. 2) An orange-colored area, the embryo, showed decidedly through the shell in the middle of the lower side.

The five eggs of female No. 61030 were in a horizontal position closely surrounded by earth They were immediately beneath a piece of rotten wood and below they rested practically against the glass bottom of the dish These eggs were all much shorter than those in the other clutches. Their color was like those described above.

The eggs of female No. 61031 were in a horizontal position completely surrounded by the decayed and pulverized wood. The only large piece of wood in this dish was wedged tightly against the bottom of the dish, so that it could not have been used as a cover These eggs were practically white with lemon-yellow ends, darkest at the very tip In the middle, and appearing on top as they were uncovered, the embryo showed through the shell as an orange-colored disc

To sum up, the eggs were as deep in the decayed wood earth as could be, and, in the two cases where it was possible, they were immediately beneath a piece of old wood They were in all cases horizontal, with their long axes practically parallel

A week after the eggs were laid they were sufficiently translucent so that, on being held up to the light, the embryo and blood-vessels could be seen and the head end of the embryo identified

After deposition of the eggs the bodies of the females were very much shrunken and translucent in the region posterior to the gall-bladder, where the eggs had lain in the oviducts

At no time was any one of the parents observed to pay the slightest attention to her eggs Parental care is not illustrated by Figure 5 (Pl XXIII), but only relative size of eggs and adult

The dimensions of the eggs are given in Table II, and their shapes and relative positions when found are shown in Figures 1 to 4 The first five photographs were taken by Frances J Dunbar, and the last two by the writer.

The hatching of these eggs was a prolonged and interesting process. At 9·15 A.M, September 9, a young snake was found protruded about two-thirds of its length (Fig 7) from one of the eggs of female No. 61027 The snake remained in this position until 10 15 A M., September 11, when it slowly pulled its tail free from the egg, at the same time exploring the soil with its head. This one shed its skin about September 21. The other egg of this set was the only egg, in all four sets, that did not hatch.

At 12 15 P M, September 16, one egg of female No 61028 had started to hatch There were four cracks in it This egg was observed several times during the morning and there was no break in it then. At 9.30 A.M. the next day, the snake from the other egg of the clutch was all the way out of its shell but attached to the egg by the yolk stalk (as in Fig. 7). The egg which had first cracked, hatched some time between noon and 3 00 P M of that day (September 17), emergence thus being completed in a little more than 24 hours The second snake remained attached to the yolk stalk until after 5 00 P M, September 17 The next morning at 9 00 A M it was off, and buried in the loose earthy material in the cage

Two eggs of the set of five (61030) were found hatching at 10 00 A M., September 14 The tip of a snout was protruding from each One young snake remained projecting thus quietly from the same opening for the considerable period required for photographing the eggs, while the other was rather active within the egg. The head of the latter individual was protruded at various times from at least four different places, including both ends of the egg At one time during the photographing this snake projected its body about one-fifth of the way out, then withdrew partially, and finally completely Later its snout was thrust out in another place (Fig. 6). The shell is very thin and it is quite apparent that movements within the egg are sufficient to crack it

A third egg of this set started to hatch about 4 15 P M, September 14. At 10·15 A M the next day it had not yet hatched, but both of the first two young snakes were out, and a fourth egg had a young snake projecting half an inch from it The third snake came out of the shell about 4.30 P M, September 15, thus taking about 24 hours for its complete emergence The fourth was out before 9 45 A M, September 16, and the fifth now had its head out of the shell. The latter was out at 9·30 A M. the next day

At 9·45 in the morning of September 13, one egg of female No. 61031 had a lengthwise slit near one end and a snout slightly protruding. When this egg was posed for its photograph, the snout withdrew. An hour later it had appeared in a new slit near the middle of the egg This egg was left under a bell-jar for about six hours, at the end of which time the snout was found to be dried fast into the opening of the shell. The egg was wetted and put back into its proper dish. The next morning at ten o'clock it was in good condition, and the snout was out in the same place. At a touch it withdrew for a long time The other egg now had two slits, from one of which a snout projected. The next morning (September 15) at 10 15, both young snakes were out.

It is obviously not easy to know just when the first slit appears in an egg and just when the young snake finally emerges, but the foregoing observations indicate that this interval is from about one-half a day to two days, with an average of, perhaps, one day Apparently the movements of the young snake, as it matures, cause cracks in the shell These cracks are oftenest due to thrusts of the snout against the shell, but may also be due to movements of the body Complete emergence depends upon the increasing strength of the young snake and its release from the embryonic membranes

As soon as the young Carphophis is completely released from its embryonic home it burrows quickly out of sight These young worm snakes were kept alive for several weeks, but never once were they in sight when there was anything under or in which to hide

The little snakes of female No 61030 were a very shiny, warm, blackish-brown above and a less shiny Corinthian pink below.[1] The others were similar in coloration After a few days their skins became more milky and about one week after hatching, a little before September 23, all had shed their skins

In a week or two after their birth, very small earthworms were offered to the little snakes The latter were buried in soft wood earth, and uncovering them frightened them so much that they would not eat. They were, therefore, transferred to dishes with only a few pieces of moist bark for cover. When the young snakes could be exposed without disturbance they would take the small worms readily, and thus they were fed for many weeks.

Immediately after hatching, the young Carphophis were measured and their scales were counted These figures are all tabulated in the appended list of Carphophis specimens, and the measurements alone are given in Table II. These measurements, when compared with the dimensions of the eggs, show, as would be anticipated, that the largest snakes are hatched from the largest eggs

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[1] Ridgway, Robert. 1912 *Color Standards and Color Nomenclature*

The foregoing observations are recorded here in considerable detail because they seem in large part to be the first of their kind for any species of snake Many more records of this sort are needed as a basis for any trustworthy conclusions Some tentative results of the present study of laying and hatching of eggs of *Carphophis amoena helenae* may be summarized as follows

1 This species lays from two to five eggs, so far as known at present Two females that were preserved as soon as collected had three and five eggs in their oviducts, ready to be laid

2 The eggs, upon deposition, are not stuck to one another, as in many species of snakes, but are entirely separate, and lie nearly parallel to one another

3 The mother pays no attention whatever to her eggs

4 The eggs, from one clutch to another, are nearly constant in width, but vary greatly in length

5 The shortest eggs are in the largest clutches.

6. The eggs increase in size after deposition The greatest relative increase is in the width

7. The largest young hatch from the largest eggs

8 Both deposition and hatching occur within relatively narrow time limits

9. The period of incubation outside the body of the mother is about two months

Some remarks on the scutellation of these twenty-six adult and young worm snakes from southern Indiana may now be in order. Only a single one of this series of specimens has the prefrontal plates separate from the internasals It has been recently pointed out by the writer (1925, p 528) that the known specimens of *Carphophis amoena helenae* exhibit a constancy of 89 per cent in the fusion of internasals and prefrontals — the subspecific character which distinguishes this subspecies from *C amoena amoena*. The present series of specimens increases this constancy to about 91 per cent, thus slightly strengthening the

## TABLE I

### DEPOSITION AND HATCHING OF EGGS OF CARPHOPHIS AMOENA HELENAE

| Museum number of parent | Date of deposition | Number of eggs deposited | Date of hatching | Number hatched |
|---|---|---|---|---|
| 61027 | July 4–7 | 2 | Sept 9–11 | 1 |
| 61028 | July 7–11 | 2 | Sept 16–17 | 2 |
| 61030 | July 7–11 | 5 | Sept 14–17 | 5 |
| 61031 | July 7–11 | 2 | Sept 13–15 | 2 |

## TABLE II

### MEASUREMENTS OF EGGS AND YOUNG OF CARPHOPHIS AMOENA HELENAE

| Museum number of parent | Dimensions of eggs in millimeters | | | | Lengths of newly hatched young in millimeters |
|---|---|---|---|---|---|
| | Length | | Width | | |
| | At laying | Sept 12 | At laying | Sept 12 | |
| 61027 | 20 5–21 | 22 | 7 5–8 | 10 | 87 |
| 61028 | 23–24 | 26–28 | 8 | 12 | 93–100 |
| 61030 | 17–19 | 18 8–20 9 | 7 5–8 | 10 4–11 5 | 89–97 |
| 61031 | 27–27 5 | 29–31 3 | 8 5–9 | 11–12 9 | 105 |

## TABLE III

### SPECIMENS OF CARPHOPHIS AMOENA HELENAE COLLECTED IN SOUTHERN INDIANA

| Number | LOCALITY | Collected June | Sex | Ventrals | Caudals | Posterior temporals | Total length | Tail length |
|---|---|---|---|---|---|---|---|---|
| 61017 | 5 mi E of Bloomington | 5 | female | 121 | 29 | 2, 2 | 256 | 41 |
| 61018 | Near Donaldson's Cave | 6 | male | 118 | 34 | 2, 2 | 238 | 45 |
| 61019 | " " " | " | " | 117 | 33 | 2, 2 | 261 | 48 |
| 61020 | " " " | " | " | 120 | 34 | 2, 2 | 239 | 47 |
| 61021 | Perry Twp , Vanderburg County | 13 | " | 125 | 32 | 2, 2 | 121 | 19 |
| 61022 | " " " " | 12 | " | 123 | 36 | 2, 2 | 250 | 47 |
| 61023 | " " " " | " | female | 133 | 28 | 2, 2 | 273 | 40 |
| 61024 | Near Donaldson's Cave | 19 | male | 118 | 33 | 2, 2 | | |
| 61025 | " " " | " | " | 119 | 36 | 2, 2 | 216 | 40 |
| 61026 | " " " | " | " | 116 | 35 | 2, 2 | 243 | 48 |
| 61027 | " " " | " | female | 129 | 26 | 1, 2 | 275 | 39 |
| 61028 | " " " | " | " | 128 | 26 | 2, 2 | 249 | 33 |
| 61029 | " " " | " | " | 124 | 24 | 2, 2 | 247 | 30 |
| 61030 | " " " | " | " | 125 | 27 | 2, 2 | 283 | 49 |
| 61031 | " " " | " | " | 130 | 25 | 1, 2 | 267 | 37 |
| 61032 | " " " | " | male | 115 | 36 | 2, 2 | 230 | 45 |
| 61033 | From egg laid by 61027 | | " | 121 | 33 | 2, 2 | 87 | 15 |
| 61034 | " " " " 61028 | | " | 118 | 36 | 2, 2 | 93 | 16 |
| 61035 | " " " " " | | " | 121 | 83 | 2, 2 | 100 | 16 |
| 61036 | " " " " 61030 | | female | 127 | 30 | 2, 1 | 89 | 13 |
| 61037 | " " " " " | | male | 121 | 36 | 1, 2 | 97 | 15 |
| 61038 | " " " " " | | female | 131 | 28 | 2, 2 | 94 | 13 |
| 61039 | " " " " " | | male | 122 | 35 | 2, 2 | 93 | 16 |
| ——— | " " " " " | | " | 121 | 33 | 2, 2 | 90 | 15 |
| 61040 | " " " " 61031 | | female | 129 | 27 | 1, 1 | 105 | 14 |
| 61041 | " " " " " | | male | 124 | 36 | 1, 1 | 105 | 20 |

case for subspecific distinction The dorsal scale rows of all specimens number 13 throughout the length of the body The upper labials are 5 in every case, except the left side of the head of No 61024, where they are 6 The lower labials are 6 in every instance The long loreal plate is in contact with the eye in every case, except in specimen No 61021 Here a preocular is cut off from the loreal on each side There is a single postocular in every specimen The light ventral color extends in most cases to the lower half of the second scale row, but in some instances only to the upper part of the first row and in others to the upper part of the second row

There is little evidence of conspicuous resemblance between offspring and parent However, the mother numbered 61028 and both of her young have the ventral light color reaching only to the top of the first scale row This mother is the one individual with separate prefrontals and internasals In both offspring these plates are fused, but in one of the two (61035) a depressed line extends a short distance to the left of the common prefronto-internasal suture, at the exact point where an internasal plate would be cut off Other features of scutellation and measurement can be noted in the accompanying list of specimens

DIADOPHIS PUNCTATUS EDWARDSII (Merrem).—A small specimen (61000) was found coiled on damp earth and rotted wood under the overhanging edge of a large rotting log, in heavy woods, Perry Township, Vanderburg County, Indiana, June 12, and a small adult (61002) was taken from under the loose bark of a fallen log above Donaldson's Cave, Mitchell, Indiana, June 19 Both specimens are males, and have 15 rows of scales throughout the body length, 8 lower labials, 2 preoculars, 2 postoculars, and 1 anterior and 1 posterior temporal scute Other characters of the two specimens are, respectively, as follows ventrals, 152 and 149; caudals, 50 and 48, upper labials, 8 and 7, width of neck ring in scale lengths, 2 and 1¼, total lengths, 135 and 214 mm.; tail lengths, 27 and 46 mm The first is unspotted below, the second has an interrupted series of small black spots in the median line on the posterior half of the body. Both specimens may be regarded as typical of the subspecies

Coluber constrictor constrictor (Linné) — A juvenile male (61003), measuring 436 mm in length with tail 111 mm long, was found lying in the road on the outskirts of Bloomington, Indiana, June 20 The juvenile pattern of dorsal spots is almost indistinguishable, on the lower side, the half-circular black spots on the ends of the ventrals are conspicuous on the forward portion of the body, but diminish to disappearance near the posterior end The scale rows are 17–15, the ventrals, 176, the caudals, 98, the labials, 7 above and 8 below

Elaphe obsoleta obsoleta (Say) — A juvenile female (61005) was found near the edge of a wooded road at dusk, June 18, near Donaldson's Cave, Mitchell, Indiana Its total length is 576 mm , and its tail is 102 mm long There are 31 well-defined quadrate blotches on the body The scale rows are 25-17, the ventrals, 228, the caudals, 80, the labials, 8 above and 12 below, the oculars, 1 and 3 This specimen is referred to the subspecies, *obsoleta*, on the basis of geographical probabilities, and of Hahn's statement (1908, p 565) that the adults in this region are typical of this subspecies

Elaphe obsoleta confinis (Baird & Girard) — An adult male (61006) was taken near Smith Mills, Henderson County, Kentucky, on a partly wooded road in hilly country, June 15 Its total length is 1312 mm and its tail length is 262 mm The scale rows are 27–25-17, the ventrals, 232, the caudals, 86, the labials, 8 above and 11 below, the oculars, 1 and 2 There are 32 well-defined quadrate blotches on the body.

Lampropeltis getulus nigra (Yarrow) — A juvenile male (61007) was found on the ground under a piece of bark in a woods clearing in Perry Township, Vanderburg County, Indiana, June 12. It is 489 mm. in total length, and its tail is 69 mm long. The scale rows are 21–19–21–19, the ventrals, 207, the caudals, 51; the labials, 7 above and 8 below, the oculars, 1 and 2, and the temporals 2 + 3. There are about 63 narrow cross-bands on body and tail. There are no yellow spots between the cross-bands

An adult male (61008) was found crossing the road between a field and a woods early in the morning of June 18, near the East Fork of the White River, between Loogootee and Shoals, in Martin County, Indiana The place is locally known as Hindoostan Falls This specimen was true to the reputation of its species in being a mild-mannered snake to handle Its total length is 880 mm., and its tail length is 118 mm Its scale rows are 19–21–19, the ventrals, 209, the caudals, 46; the labials, 7 above and 9 below, the oculars, 1 and 2, the left temporals, 2 + 3, the right temporals, 2 + 2 There are about 66 very narrow, inconspicuous cross-bars on body and tail. Between some of the cross-bars on the back are a very few minute yellow spots.

NATRIX SIPEDON ERYTHROGASTER (Forster) — An adult female (61009) was taken on the Ohio River flood-plain in a shady slough at the side of a road through wet woods, in Union Township, Vanderburg County, Indiana, June 10 On being etherized, it disgorged seven large frog tadpoles and one larval salamander, *Ambystoma microstomum* Its body is 810 mm in length The tail is incomplete, as is frequently the case with the large species of Natrix The ventrals are 150 in number, the labials are 8 above and 10 below, the oculars are 1 and 3, the temporals are 1 + 3 The specimen is very dark above with no indication of a pattern. Below it was reddish in life, except for the ends of the ventrals and the caudals, which were clouded with a dusky color

An adult female (61010) was taken by a ditch in cypress woods on the Ohio River flood-plain near Smith Mills, Henderson County, Kentucky, June 15. Its total length is 1142 mm., its tail length, 240 mm The scale rows are 23–25–16 (the median row is lost about 11 scales from the posterior end of the body), ventrals, 153; caudals, 71, labials, 8 above and 10 below; left oculars, 1 and 4, right oculars, 1 and 3; temporals, 1 + 3. The coloration is the same as that of the last one mentioned.

An adult male (61011) was collected by a pool in the same cypress woods as the last, and on the same day. It is 953 mm, in total length, and the tail is 231 mm long, the tip of the latter, however, is missing The scale rows are 21-23-17, the ventrals, 146; the caudals, 81 (with one or two probably missing), the labials, 8 above and 10 below, the oculars, 1 and 3, and the temporals, 1 + 3

NATRIX SIPEDON SIPEDON (Linné) — A juvenile of typical pattern (61012) was taken 3 miles west of Nashville, Indiana, June 20. It is 258 mm. in total length, and its tail is 67 mm long The scale rows are 23-19; the ventrals, 140, the caudals, 76, the labials, 8 above and 10 below, the oculars, 1 and 3, and the temporals, 1 + 3

STORERIA OCCIPITO-MACULATA (Storer) — One male (61013) was found crawling through leaves at the base of an oak tree near Twin Caves, Mitchell, Indiana, June 20 It is 213 mm in total length, and its tail is 53 mm long The dorsal scales are in 15 rows throughout the body length, the ventrals are 119, the caudals, 56, the labials, 6 above and 7 below, the oculars, 2 in front and 2 behind, and the temporals, 1 + 2

THAMNOPHIS SIRTALIS SIRTALIS (Linné). — An adult male (61014) was taken 2 miles west of Greensburg, Indiana, June 4, an adult female (61015) was found three feet high in a bush at the edge of a road in the low land of Union Township, Vanderburg County, Indiana, June 10, and another adult female (61016) was taken at Smith Mills, Henderson County, Kentucky, June 16. In each specimen the scale rows are 19-17, the labials, 7 above and 10 below, the oculars, 1 and 3, and the temporals, 1 + 2. The ventrals are 150, 147 and 151, the caudals, 63, 55 and 64, the total lengths, 577, 558 and 730 mm, and the tail lengths, 125, 110 and 158 mm, respectively.

CHELYDRA SERPENTINA (Linné). — One rather small individual (60988) was taken in the cypress woods near Smith Mills, Henderson County, Kentucky, June 15

TERRAPENE CAROLINA CAROLINA (Linné) — Box turtles were found frequently in or near woods. Collections were as follows one half-grown individual (60978) in the road 2 miles west of Nashville, Indiana, June 5, one small one (60979) under the edge of a chunk of wood at the margin of a clearing in deep woods, and a half-grown one (60980) from under a log by a small stream in the same woods, Perry Township, Vanderburg County, Indiana, June 12, an adult (60981) 7 miles southwest of Evansville, Indiana, June 13, a small one (60982) and a large one (60983) in a cypress woods in Henderson County, Kentucky, June 15, an adult (60984) in the road 5 miles north of Evansville, Indiana, June 17, one adult (60985) in the woods above Donaldson's Cave, Mitchell, Indiana, June 19, and two adults (60986–87) about 7 miles west of Nashville, Indiana, June 21

AMYDA SPINIFERA (Le Sueur) — An adult of this species (61060) was collected in a shallow river 10 miles west of Columbus, Indiana, on June 21

UNIVERSITY OF MICHIGAN

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## EXPLANATION OF PLATES

### PLATE XXII

FIGS 1–4 Eggs of *Carphophis amoena helenae*, in the positions in which they were found. Accompanying scale is in centimeters and millimeters. Fig 1 shows eggs laid by female No. 61027, Fig 2, eggs laid by No 61028, Fig 3, eggs laid by No. 61030, Fig 4, eggs laid by No 61031

### PLATE XXIII

FIG 5 *Carphophis amoena helenae*, No 61031, and her two eggs The figure shows the relative size of eggs and parent There is no evidence that the parent gives any attention to her eggs

FIG 6. Hatching of two of the eggs deposited by *Carphophis amoena helenae* No. 61030. The head of each snake can be seen projecting from the right-hand end of each egg Millimeter scale at left

FIG. 7 Hatching of one of the two eggs of *Carphophis amoena helenae* No 61027 The young snake has emerged as far as possible from the collapsed shell, but is not yet free from the yolk stalk. The egg to the right has not begun to hatch.

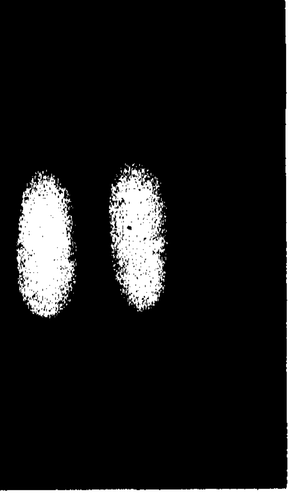


Fig. 1

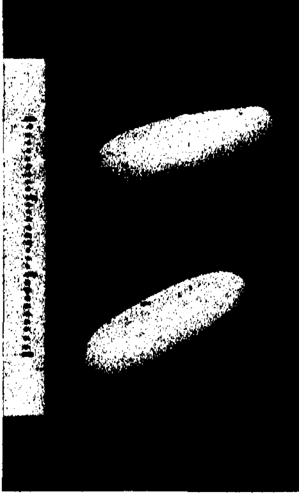
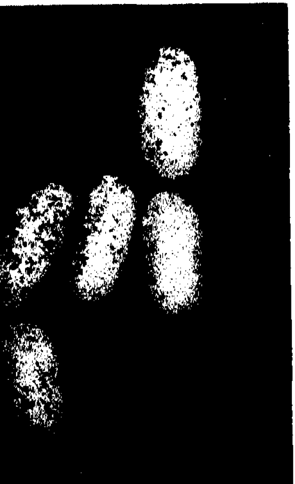
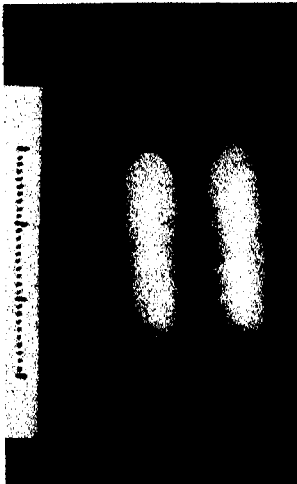


Fig. 2





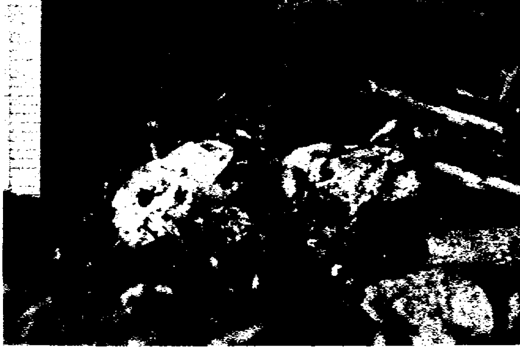


FIG. 6

# ODONATA COLLECTED IN CHEBOYGAN AND EMMET COUNTIES, MICHIGAN *

## C FRANCIS BYERS

IN a brief period of time, extending from June 21 to August 12, 1924, the author endeavored to make a survey of the Odonata of Cheboygan and Emmet counties, Michigan Particular attention was given to this group in the vicinity of the University of Michigan Biological Station on Douglas Lake, Cheboygan County Two papers have been previously published on the Odonata of the Douglas Lake region. The first (O'Brien, 1910) contained a list of 23 species, all of them recorded from adult specimens and verified by Mr. E. B Williamson The second (Evans, 1914) contained a list of 43 species, of which 11 were recorded from adult material, 19 from naiads, and 13 from the literature only Since these papers are somewhat incomplete and fragmentary, it was believed that the possibilities of the Odonata fauna were by no means exhausted, hence the 1924 collection. Also, a comprehensive account of the Odonata of Michigan is badly needed, and it is hoped that the present paper will serve as an introductory step toward this goal

Descriptions of this territory have been published (Reighard, 1915; Scott, 1921, and others) and repetition is, therefore, not necessary here.

The author wishes to express his indebtedness to Dr Paul S Welch for general directions in the preparation of this report, to Mr. Frederick M. Gaige for the use of material from the Museum of Zoölogy, University of Michigan; and to Mr. E. B Williamson for the identification of a few of the species and for verification of the author's identification of a large part of the remainder.

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* Contribution from the University of Michigan Biological Station, and from the Zoölogical Laboratory, University of Michigan.

## **Suborder:** ZYGOPTERA

### **Family:** *Agrionidae*

1 AGRION AEQUABILE (Say) —Locally abundant along Maple River Not taken elsewhere

2 AGRION MACULATUM Beauvais —More abundant than *A aequabile* Limited to banks of streams Not as plentiful as expected

### **Family.** *Coenagrionidae*

3 LESTES CONGENER Hagen —One male reared from naiad taken at Sedge Point Pools

4 LESTES DISJUNCTUS Selys — Three males taken near Chamaedaphne thickets at Bryant's Bog and at Cecil Bay.

5 LESTES FORCIPATUS Rambur. —Taken over swamps toward last of July

6. LESTES RECTANGULARIS Say —Appeared toward beginning of August in sheltered shady spots along creeks. Not common

7. LESTES UNCATUS Kirby —Common Found during June, July and August

8. ARGIA VIOLACEA (Hagen). —Collected late in season along Maple River and Bessey Creek Flying among high grasses near water margin

9 ENALLAGMA CALVERTI Morse —Not uncommon Found over extensive area and in a variety of habitats

10 ENALLAGMA CARUNCULATUM Morse —Found commonly around all bogs and pools

11 ENALLAGMA EBRIUM (Hagen). —Common, after middle of July.

12. ENALLAGMA EXSULANS (Hagen). —Four males taken in late July and early August

13. ENALLAGMA HAGENI (Walsh). —Most common species of Enallagma in region

14. NEHALENNIA IRENE Hagen. —Favors reeds and grasses along edges of ponds and bogs.

15 Amphiagrion saucium (Burmeister) — One male taken at Maple River, July 3

16 Chromagrion conditum (Hagen) — Abundant at Brown Lake, but nowhere else Collected on the sphagnum mat surrounding lake Congregated on portion of mat shaded by very dense stand of *Abies balsamia*

17 Ischnura posita (Hagen) — Three males taken at Bessey Creek, August 7

18 Ischnura verticalis (Say) — Common throughout the rest of summer after the first of July

## Suborder: ANISOPTERA

### Family: *Aeshnidae*

19 Cordulegaster maculatus Selys — Emmet County, Big Stone Bay Run Collected July 6 and July 20 More abundant on latter date Ceaselessly flying up and down creek just above water's surface

20 Progomphus obscura (Rambur) — Common along sandy beaches of Douglas and Burt lakes Emerging in numbers in early July

21 Hagenius brevistylus Selys — Tenerals first appeared in Douglas Lake beach drift after storm on July 2 Common thereafter.

22 Gomphus brevis Hagen — Collected in June along Douglas Lake and in aspen barrens

23 Gomphus exilis Selys — Scarce. June 26, one male naiad picked up on shore of Douglas Lake, emerged in laboratory two days later.

24. Gomphus spicatus Hagen. — One female on July 2 Reese's Bog

25 Gomphus sordidus Hagen. — Most common Gomphus of region Abundant in sunny aspen barrens, along with *G ventricosus*.

26. Gomphus ventricosus Walsh — Not uncommon. Appeared with foregoing species early in June, in aspen barrens. Rarely seen after July 15.

27. **Dromogomphus spinosus** Selys — Naiads and adults common.
28. **Boyeria vinosa** (Say) — One teneral female taken at Fontanalis Run, August 8 One male observed on August 10, not captured.
29 **Basiaeschna janata** (Say) — Collected along Maple River in July
30 **Anax junius** (Drury) — This well-known species rare in this region in 1924 Found only at Munro Lake on July 28. Previously reported as common (Evans, 1914, p 50).
31 **Aeshna canadensis** Walker — Rather abundant along sunny paths in hardwoods
32 **Aeshna interrupta** Walker — Naiads taken from water-lily zone of Nichol's Bog No adults captured
33 **Aeshna umbrosa** Walker — Taken with *A canadensis* flying along paths in hardwoods somewhat back from lake front Females observed ovipositing in permanent beach pools
34 **Aeshna verticalis** Hagen — One female taken at Big Stone Bay.

### Family: *Libellulidae*

35 **Didymops transversa** (Say) — Collected along edge of aspen barrens near Douglas Lake An early form abundant late in June
36. **Macromia illinoiensis** Walsh. — Emerging when the collection was begun on June 21 Spider-like naiads, on leaving water to emerge, crawl inland a distance of 25–40 feet to cottages along Douglas Lake, ascend the sides, usually continuing to the cornice, some eight feet from the ground From here they emerge. Almost any morning in June or early July one could gather large numbers of the exuviae from the sides of houses.
37. **Epicordulia princeps** (Hagen). — One male naiad found on beach at Douglas Lake; emerged in laboratory, June 28. Naiad closely resembles that of Macromia.
38 **Neurocordulia obsoleta** (Say) — A teneral male collected at East Point Pools on June 26. "This species seems to be

everywhere rare There are very few specimens in collections" (Needham, 1901, p 509) A new record for Michigan

39 Tetragoneuria canis Maclachlan — One female was taken at entrance of Reese's Bog, near Burt Lake, July 10 A rare species

40 Tetragoneuria simulans Muttkowski. — Rather abundant all summer

41 Tetragoneuria spinigera Selys — Fairly common

42. Somatochlora sp (?) — Two females and one male in 1924 collection, from both Emmet and Cheboygan counties Owing to fact that Dr E. M Walker, University of Toronto, is at the present time revising this genus, no specific names have been attached to these three specimens

43 Ladona exusta (Say) — An early form, common around marshes, bogs and swamps all summer.

44 Libellula pulchella Drury — First observed on July 21 at Cecil Bay Common during August.

45 Libellula quadrimaculata Linné — Abundant around nearly dry swamps.

46 Nannothemis bella (Uhler) — Smallest North American anisopteran Weak and sluggish. Prefers to remain at rest upon grasses or reeds, seldom flies high above them Found from Florida to Quebec, but confined to local areas of a few square yards near margins of lakes or streams Two males taken at Cecil Bay not more than fifty yards from shore of Lake Michigan, July 21

47. Sympetrum corruptum (Hagen) — Flying among tall bullrushes (Scirpus) growing along edges, and in quiet bays of larger lakes.

48 Sympetrum costiferum (Hagen). — Very late form First observed at mouth of Bessey Creek, August 7.

49. Sympetrum obtrusum (Hagen) — Very common.

50. Sympetrum rubicundulum (Say) — Common.

51. Leucorrhinia frigida Hagen. — Three males taken. one at Cecil Bay, two at Bryant's Bog Flying among taller grasses back from water's edge.

52. Leucorrhinia hudsonica (Selys) — One male taken at

Brown Lake, July 28 Found with *L proxima* and *Chromagrion conditum*

53 LEUCORRHINIA INTACTA Hagen — Rather common after second week in July Found flying over small lakes and ponds, especially prone to alight on Chamaedaphne bushes near water's edge

54 LEUCORRHINIA PROXIMA Calvert — Closely associated with *L intacta* Especially abundant around Nichol's Bog

These fifty-four species complete the list of Odonata that were taken by the writer during the summer of 1924. The collection has been deposited in the Museum of Zoology of the University of Michigan

### SUMMARY

The fluctuation of species from year to year must be considerable, to judge from collections made over this territory in past years (O'Brien, 1910, Evans, 1914) A synoptic table of the complete Odonata record of Cheboygan and Emmet counties follows.

## TABLE I

### COMPLETE RECORD OF SPECIES

In this Table *A* signifies species recorded from adult material, *N*, from nymphal material, *L*, from the literature Museum = Museum of Zoology, University of Michigan The author has examined the material upon which Columns 1 and 4 are based The specimens that supplied data for Columns 2 and 3 are no longer available for examination

| No | Species | Byers, '24 | Evans, '14 | O'Brien, '10 | Museum |
|---|---|---|---|---|---|
| 1 | Agrion aequabile | A | A | | |
| 2 | Agrion maculatum | A | A | | |
| 3 | Hetaerina americana | | A | | |
| 4 | Lestes congener | A | | | |
| 5 | Lestes disjunctus | A | L | A | |
| 6 | Lestes rectangularis | A | A | | |
| 7 | Lestes unguiculatus | | A | A | A |
| 8 | Lestes uncatus | A | L | A | |
| 9 | Lestes forcipatus | A | L | A | |
| 10 | Argia violacea | A | | | |
| 11 | Enallagma calverti | A | | | |
| 12 | Enallagma carunculatum | A | L | A | |
| 13 | Enallagma ebrium | A | | | |
| 14 | Enallagma exsulans | A | N | A | |
| 15 | Enallagma hageni | A | | | |
| 16 | Chromagrion conditum | A | | | |
| 17 | Nehalennia irene | A | L | A | |
| 18 | Ischnura posita | A | N | | |
| 19 | Ischnura verticalis | A | N | A | |
| 20 | Amphiagrion saucium | A | | | |
| 21 | Cordulegaster maculatus | A | | | |
| 22 | Progomphus obscura | A | N | A | A |
| 23 | Hagenius brevistylus | A | N | A | A |
| 24 | Ophiogomphus carolus | | N | | |
| 25 | Ophiogomphus rupinsulensis | | | | A |
| 26 | Gomphus brevis | A | | | |
| 27 | Gomphus exilis | A | | | |
| 28 | Gomphus scudderi | | L | A | |
| 29 | Gomphus spicatus | A | N | | |
| 30 | Gomphus descriptus | | N | | |
| 31 | Gomphus sordidus | A | | | |
| 32 | Gomphus vastus | | N | | |
| 33 | Gomphus ventricosus | A | L | A | |
| 34 | Dromogomphus spinosus | A | N | A | A |

TABLE I — *Concluded*

| No | Species | Byers, '24 | Evans, '14 | O'Brien, '10 | Museum |
|---|---|---|---|---|---|
| 35 | Boyeria vinosa | A | N | A | |
| 36 | Basiaeshna janata | A | A | | |
| 37 | Anax junius | A | A | A | |
| 38 | Aeshna canadensis | A | L | A | A |
| 39 | Aeshna constricta | | N | | |
| 40 | Aeshna interrupta | N | L | A | A |
| 41 | Aeshna umbrosa | A | | | |
| 42 | Aeshna verticalis | A | | | A |
| 43 | Aeshna eremita | | | | A |
| 44 | Epiaeschna heros | | A | | |
| 45 | Didymops transversa | A | | | |
| 46 | Macromia illinoiensis | A | N | A | |
| 47 | Epicordulia princeps | A | N | | |
| 48 | Neurocordulia obsoleta | A | | | |
| 49 | Tetragoneuria canis | A | | | |
| 50 | Tetragoneuria spinigera | A | N | | |
| 51 | Tetragoneuria simulans | A | | | |
| 52 | Cordulia shurtleffi | | N | | |
| 53 | Somatochlora sp ? | A | | | |
| 54 | Ladona exusta | A | | | |
| 55 | Libellula pulchella | A | A | | |
| 56 | Libellula cyanea | | N | | |
| 57 | Libellula quadrimaculata | A | | | |
| 58 | Sympetrum assimilatum | | L | A | |
| 59 | Sympetrum costiferum | A | L | A | |
| 60 | Sympetrum corruptum | A | | | |
| 61 | Sympetrum obtrusum | A | L | A | |
| 62 | Sympetrum rubicundulum | A | A | A | |
| 63 | Sympetrum scoticum | | L | A | |
| 64 | Leucorrhinia intacta | A | | | |
| 65 | Leucorrhinia proxima | A | | | |
| 66 | Leucorrhinia hudsonica | A | | | |
| 67 | Leucorrhinia frigida | A | | | |
| 68 | Pachydiplax longipennis | | N | | |
| 69 | Nannothemis bella | A | | | |
| 70 | Celithemis eponina | | N | | |
| 71 | Tramea lacerata | | N | | |
| | Total | 54 | 43 | 23 | 10 |

This list of seventy-one species, the total number recorded for Cheboygan and Emmet counties, will no doubt be added to from time to time, since student-collectors are yearly in the field, especially in the Douglas Lake territory In order to make this number more significant the following Table has been prepared

TABLE II

NUMBER OF SPECIES

| Region | Authority | Date | No Species |
|---|---|---|---|
| World | Muttkowski | 1910 | 2,631 * |
| North America | Muttkowski | 1910 | 494 * |
| New England states | Howe | 1920 | 156 |
| Indiana | Williamson | 1917 | 125 |
| Michigan, Schoolcraft Co | Combs | 1917 | 49 |

* Including subspecies

In view of the forty-nine species from Schoolcraft County, together with those from the other counties, the prospect of a large list of Odonata for the State is hopeful, since diligent collecting in the counties farther to the south will undoubtedly yield many additions.

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# THE PHYSIDAE OF THE AU SABLE RIVER, MICHIGAN

WILLIAM J CLENCH

THE Physidae discussed in this paper were collected incidental to a survey of the fish fauna of the Au Sable River and its tributaries, which was made in the summer of 1924 and the spring of 1925 by Mr C L Hubbs, J Metzelaar, T L Hankinson and T. H Langlois Though by no means complete, the collection and accompanying data give a general idea of the extent and distribution of the family in this particular river-system

The results of similar work, dealing primarily with the number of species, the extent of distribution and the relationship of the species concerned, relative to surveys of families or genera, have been published by Ortmann (1909, 1918), Harper (1886), Goodrich (1922) and others The value of these studies lies in the fact that they materially extend our knowledge of the distribution and the habits of the species

The Au Sable River drains portions of eight counties, the main river flowing through Crawford, Oscoda, Alcona and Iosco, the tributaries draining small sections of Otsego, Roscommon, Montmorency and Ogemaw. Many of the tributaries have their origin in lakes and the river itself has been dammed in several places, creating artificial lakes that have an interesting bearing on some ecological problems in this family

Four species and one variety were collected, and it is very possible that others may be found upon further investigation *Physa gyrina* Say, the most common species in the family, was collected throughout the whole system, occurring in many types of habitat and exhibiting considerable variation *P integra* Hald was also collected from numerous localities, but not so commonly as *P. gyrina* Both of these species were collected in the upper end of Mio Pond, one of the artificial lakes Neither species is a true lake form, though commonly reported as such in the literature They are very often associated with lakes, but I have found them usually in the small beach pools or very small coves in protected places about a lake They are not usually found along the open, unprotected beaches of lakes, as is *P sayii* Tapp and the many varieties of *P ancillaria* Say The specimens from Mio Pond were collected in such a protected section They are possibly remnants of the river fauna which existed there before the building of the dam They differed from material collected at other stations in being more inflated or globose, a character associated with the true lake species. Most of the *P gyrina* collected are quite elliptical in outline and represent the species described by Tryon as *P oleacea* I agree with Baker (1)[1] that *P oleacea* is synonymous with *P gyrina* In many cases large numbers of *P gyrina* were collected and a complete series from half-grown to fully adult specimens exhibited this character

### PHYSA SAYII Tapp.

Chub Creek, near source in a small lake, Otsego Co., West Twin Lake, Montmorency Co ; Au Sable River on lower side of Loud Dam and near mouth at Oscoda, Iosco Co.

These lots are typical for the species, which is very common throughout Michigan, usually found crawling over stones along the open beaches Though found abundantly in shallow water, it is often found in water 20 to 25 feet in depth. I have collected specimens at this depth in Pleasant Lake, Washtenaw County, on aquatic plants.

### PHYSA ANCILLARIA CRASSA Walker

West Twin Lake, Montmorency Co.

Only a single dead specimen of this species was collected.

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[1] Baker, F. C, p. 489 1910

### PHYSA INTEGRA Hald

Beaver Creek, Au Sable River, a fourth of a mile above Recreation Club House, East Branch near Grayling, and Au Sable River one mile below Stephen's Bridge, Crawford Co , Perry Creek, Lost Creek, upper end of Mio Pond, East Branch of Big Creek and near mouth of Big Creek, Oscoda Co , below Five Channels Dam, and Lower South Branch, Iosco Co

All of the foregoing are typically *P integra* with the exception of the Mio Pond material These are more inflated than those figured by Haldeman (6),[2] and the spire is not so elevated

### PHYSA MICHIGANENSIS Clench

West Branch of Big Creek, Oscoda Co.

This lot is typical of the species It is a purely small-creek form It is very probably an offshoot of *P integra*, but differs mainly from that species in having a more produced spire, slightly less impressed sutures and a more elongate aperture

### PHYSA GYRINA Say

Farm Lake, an outlet of Linn Lake, Otsego County, Au Sable River above Wakeley Bridge, Beaver Creek, and North Branch of Au Sable River and its tributary Big Creek, Crawford County, South Branch of river at Roscommon, Roscommon County, East Branch of Big Creek near Luzerne, and mouth of Big Creek, Lost Creek, Mio Pond, Au Sable River below Mio and Perry Creek, Oscoda County, Au Sable River above Alcona Pond, lower end of Alcona Pond, and pools just below Alcona Dam, Alcona County, Lower South Branch, Loud Pond, Au Sable River below Five Channels Dam, and the river and muddy ponds near Oscoda, Iosco County

Most of the lake and pond material of this species differed from the stream and river forms in being more globose and usually a little larger. However, as far as could be ascertained from the notes, few specimens from lake or pond localities were obtained in open situations, being generally collected in habitats protected by conformation of the shore line or by aquatic plants, or in the close vicinity of such situations

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[2] Haldeman, S S , Pl 4, Figs 7 and 8. , 1843

Presumably the most adaptive species in the whole family is *P gyrina,* and it is a species having the greatest amount of variation Baker (2)[3] holds that the environment is capable of causing a change in Physa in a single generation In a small measure, I think that this is probably true Young *P integra* collected in swift water and placed in a still-water aquarium have developed characters slightly different from adult specimens of the same species collected in the same locality. True swift-water or deep-water forms are usually shouldered and have a very low spire *P integra,* developed under laboratory conditions, had a much longer spire and lacked the shoulder A change in any one species under different environmental conditions may affect many of its characters in a different way Thus, the shallow-water forms of *P integra* found in creeks differ from the deep-water forms in having a more produced spire, but lake forms of the same species are more globose and have a comparatively shorter spire It is more than possible that these changes in shell characters are accompanied by changes in the soft parts as well In a previous paper (3, 1925) I have explained other changes in form in a similar way

Many problems connected with the study of fresh-water mollusks are difficult to solve experimentally Numerous factors are involved and the difficulty of duplicating portions of the natural environment makes it hard to point with any degree of certainty to the direct causes of character changes. While assumptions do not satisfy, they do help until more satisfactory experimental evidence can prove or disprove them.

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[3] Baker, H B., p. 211 1912.

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# THE ESTABLISHMENT OF THE ATLANTIC SMELT IN THE UPPER WATERS OF THE GREAT LAKES

CHARLES W. CREASER

## I. INTRODUCTION

SINCE 1906 several attempts have been made to introduce smelt (*Osmerus mordax*) into the upper waters of the Great Lakes At least two of these attempts have been successful and the species is now spreading from one of these centers, if not from both At each of these places the fish is now propagating itself and has become a true addition to the fauna It is the purpose of the present paper to present the history of this introduction of the smelt, its origin, present distribution, and several items of its life-history pertinent to the understanding of all of these points.

The first attempt to introduce this fish into the upper waters of the Great Lakes appears to have been made in the St Mary's River In 1906 the Michigan State Fish Commission sought to make a success of the introduction of landlocked salmon by the propagation of smelt as its food Their report[1] (1909) states that "a small consignment of smelt eggs from New England waters was received at the Soo hatchery last spring (1906) and deposited in the St Mary's River" This was not a success apparently as the species has never been taken in that region Since that time many attempts have been made to establish smelt in the upper waters of the Great Lakes or their contributing lakes and streams. The reports of the United States Bureau of Fisheries for 1909, 1912, 1914, 1915, 1916 and 1921 all record the Michigan State Fish Commission as the receiver of large numbers of eggs Little is known of the fate of these eggs and only a few reports have been made regarding their deposition in the waters of the State of Michigan Of the 1912 shipment the Michigan Fish Commission reports[2] that on April 4, 1912, 6,000,000 eggs were deposited in Torch Lake, Antrim County, and on April 6, 1912, 16,400,000 eggs were placed in Crystal Lake, Benzie County, Michigan It is evident that smelt became established in Crystal Lake from this planting as will be further indicated later in this report The fate of the Torch Lake planting will also be considered In 1921 the State Fish Commission of Michigan received 2,000,000 eggs, which the report[3] (1922) intimates were deposited in Lake Michigan and Lake Huron, but about which they were unable to give further information About 200,000 eggs also were sent to the Huron Mountain Club of Marquette County, the history of which will be indicated later

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[1] *Biennial Report of the State Board of Fish Commissioners* (Michigan), for fiscal years 1905–1906 (1909).

All of the eggs used in the numerous plantings in the Great Lakes region were sent to this State by the Federal Bureau of Fisheries This bureau has only one hatchery which collects smelt eggs It is located at Green Lake, Maine The smelt (Pl XXIV) is a native of this lake, many of the eggs being obtained from natural spawning The smelt of Green Lake is a native fresh-water race of the marine species common along the North Atlantic Coast It is a native of many of the fresh waters of the New England states Without doubt Green Lake, Maine, may be considered the home of all of the Great Lakes smelt.

## II DISTRIBUTION OF THE SMELT

The first specimen of smelt taken from the upper waters of the Great Lakes was received from the Michigan Department of Conservation in May, 1922 No data were included with it except that it had been sent in to the Department by Mark Craw of Traverse City. A newspaper account (*Detroit Free Press*) of April 6, 1922, described an odd fish spawning at

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[2] *Biennial Report of the State Board of Fish Commissioners* (Michigan), for fiscal years, 1911–1912 (1913)

[3] *Biennial Report of Department of Conservation* (Michigan), 1922

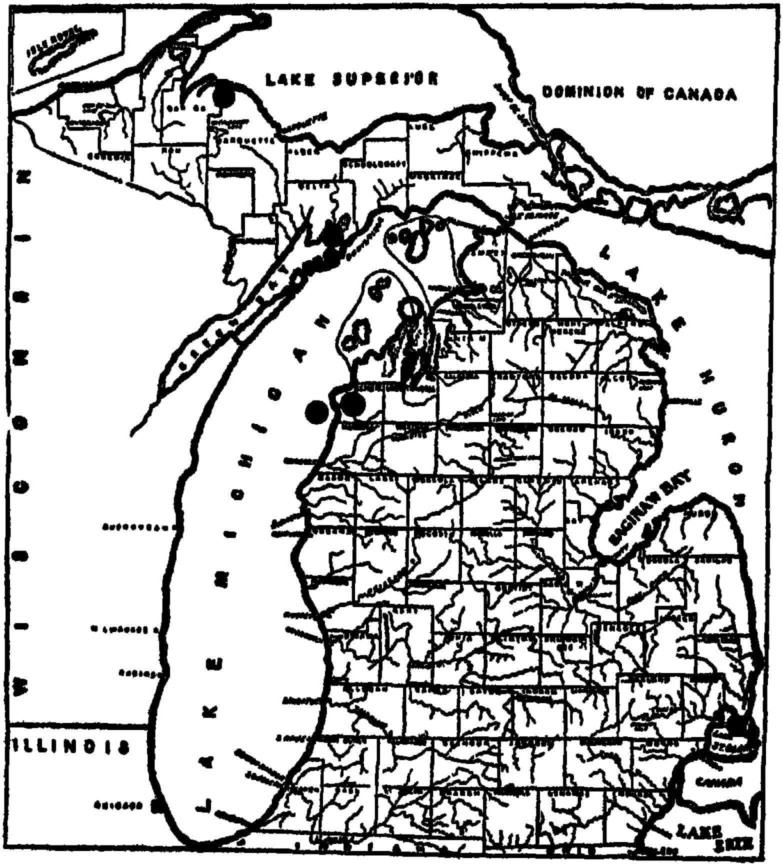

FIG. 26. Chart showing the Distribution of Smelt (*Osmerus mordax*) in the Upper Waters of the Great Lakes

Crystal Lake, Michigan, which seemed to be the smelt These records formed the basis of a note in *Copeia*[4] by T L. Hankinson and Carl L Hubbs, which called attention to the fact that the smelt was present in the Great Lakes Mark Craw has informed the writer that all the specimens that he collected came from Cold Creek at Beulah, Michigan, none were from Traverse Bay as indicated in the note referred to above.

Specimens have been taken or recorded from the following places in the upper Great Lakes basin, all of which are in the state of Michigan (see Fig 25)

1. Crystal Lake, Benzie Co, Beulah, Michigan Specimens have been taken in the lake proper in summer and winter and at a great range of depths, from a tributary, Cold Creek, at the village of Beulah, and from the outlet, East Betsie River, which runs into Lake Michigan.

2 Lake Michigan, five miles south of Frankfort, Michigan, and one and a half miles out in the lake A specimen was taken in a gill-net by the commercial fishermen, L Rodal and Sons, and sent to the writer by Mr Roy Collins These fishermen report that smelt is abundant in Lake Michigan off Frankfort.

3. Big Bay de Noc, Delta Co, Michigan One specimen sent to the Museum of Zoology by commercial fishermen of that region

4 Howe Lake and Trout Lake, Marquette Co, Michigan. Dr. Bryant Walker reported to the writer that the Huron Mountain Club planted these lakes with smelt eggs credited to them above. Dr Walter Koelz made a trip into this region from August 23 to September 2 and caught smelt in both of these lakes. They were one to four years old, which indicates that they are established in these lakes Howe Lake has no outlet, but Trout Lake drains through Pine Lake to Lake Superior. The presence of smelt is accounted for by the egg-plantings of 1912 and 1918

5 Lake Michigan at Northport, Leelanau Co., Michigan. Dr Koelz interpreted the description of a strange fish caught by fishermen of this region as that of a smelt.

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[4] *Copeia*, No. 129, 1922

This constitutes our knowledge of the distribution of smelt in the upper waters of the Great Lakes

Fine mesh gill-nets, which caught smelt at Crystal Lake, failed to take smelt in Torch Lake, Antrim Co, which was planted at the same time that Crystal Lake received eggs

The method of dispersal will be indicated under the discussion of the breeding habits It would seem that it is actively extending its range in these waters, and may soon become a common fish in the Great Lakes

## III THE ESTABLISHMENT OF THE SMELT

The establishment of smelt in Crystal Lake has been complete, since the breeding fishes taken there eleven years later, that is on April 17, 1923, were the product of natural spawning in the spring of 1919, 1920 and 1921 This was ascertained by age-determinations made from their scales[5] Fishes of two, three, four and five years were in the spawning run (see Pls XXVI, XXVII) Young of the year and one-year-old fishes have not been taken[5a] Large breeding runs in and about Beulah have occurred every spring since 1919 Many two-year-old fishes were taken April 6, 1925, which were hatched in the 1923 run here described.

It is quite certain that the smelt is well established in Howe and Trout lakes of Marquette County. The specimens collected there by Dr Walter Koelz are from one to four years old Successive plantings of smelt in any lake in the Great Lakes region are not indicated by the state or federal government reports. It is probable that they were the produce of natural spawning after the first planting

Smelt are very abundant in Crystal Lake, Howe Lake and

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[5] For a review of this method see Charles W Creaser, "The Structure and Growth of the Scales of Fishes in relation to the Interpretation of Their Life-History, with Special Reference to the Sunfish (*Eupomotis gibbosus*)," Univ. of Mich, Museum of Zoölogy, Miscellaneous Publications (*forthcoming*)

[5a] Since this paper was presented the young of the year and the one-year-old smelt have been collected at Crystal Lake. This additional data will be considered in a later report.

Trout Lake At Crystal Lake they are caught at all seasons of the year with hook and line, most frequently, however, in the winter through the ice by the perch fishermen Last winter (1924) they reported that one half of their catch was smelt In the spring at Crystal Lake large numbers come to the creeks to spawn

The Michigan State Department of Conservation, through Mr Craw, tried to catch all of the smelt that came into Cold Creek at Beulah during the run of 1925 A gate was placed at the lower end of the stream (at the point from which a photograph, Figure 3 of Plate XXV, was taken) Another gate was placed about one-fourth of a mile up-stream At night the fishes were allowed to pass the first gate and the fishermen removed them from the creek until midnight As daylight came and the fishes started to return to the lake the lower gate was closed and all of them were retained in the stream, from which they were removed during the morning and early afternoon Each person was allowed twenty pounds The game warden kept an account of the number of men at work, as nearly as was possible under the circumstances. Some estimate of the number of fishes that came into Cold Creek can be made from the data thus gathered On the average six smelt weigh one pound The value of these may be figured on the basis of whitefish prices prevailing in that region at this time.

SMELT RUN AT COLD CREEK, BEULAH, MICHIGAN, APRIL, 1925

| April | Time | Lbs (Est ) | No (Est ) | Value (at 35¢) |
|---|---|---|---|---|
| 2 | Evening | 600 | 3,600 | $ 210 00 |
| 3 | 6 A M -4 30 P M | 4,500 | 27,000 | 1,575 00 |
| 3 | 9 30 P M -11 30 P M | 2,500 | 15,000 | 875 00 |
| 4 | 4 30 P M -3 00 P M | 5,400 | 32,400 | 1,890 00 |
| 4 | 9 30 P M -12 00 P M | 1,300 | 7,800 | 455 00 |
| 5 | 9 30 A.M -12 00 A M | 1,300 | 7,800 | 455 00 |
| 6 | All day | 200 | 1,200 | 70 00 |
| 7 | All day | 100 | 600 | 35 00 |
| 8 | All day | 100 | 600 | 35 00 |
| | Total 7 days | 16,000 | 96,000 | $ 5,600 00 |

These estimates are certainly under rather than over the actual numbers They are probably quite close to the real figures.

In the other lakes the fishes were caught quite frequently in small mesh gill-nets In Lake Michigan they seem to be quite abundant, since the fishermen report that one or two are entangled in almost every set of their large mesh gill-nets Further collections are being made as part of the effort to determine the abundance of smelt in Lake Michigan

## IV THE SPAWNING OF THE SMELT IN CRYSTAL LAKE

The smelt spawns very early in the spring before the ice breaks up in the lake as a whole At Crystal Lake the spawning started on April 10, 1923, and by the sixteenth it was at its height This was somewhat later than that of 1922, which was all over by the eighth of April The run of 1925 was very heavy and was concentrated over the period of April 2 to April 8 All the fishes that entered the Creek were removed, none being allowed to return to the lake

At Beulah the smelt ran up a small permanent stream known to the residents as Cold Creek This stream is not over a mile long and has its headwaters in a cedar bog, in the portion used by the smelt, it flows through the village and enters the south end of the lake During these last few hundred feet it is a clear stream running over a sand and gravel bed with a considerable current. The current was increased at the time of spawning by flood water from the melting ice and snow Part of the lower portion of the stream was still covered by a snow-bridge This was several inches above the water level and was firm enough to carry the weight of a man Figure 1 of Plate XXV was taken from this bridge, which is in the immediate foreground From this point to the mouth of the Creek was the main spawning ground of the smelt Figure 3 of Plate XXV shows the rest of the spawning ground of the smelt It was taken from a small foot-bridge located midway between the mouth of the stream and the snow-bridge The creek here was not over two and one-half feet deep and was about ten feet wide.

It will be noticed that at its mouth the stream is much narrower because of the wave action of the lake. In the lake proper there was an open pool of water which received the flow of creek water over a delta of sand and gravel The rest of the lake was covered with thick ice Out from under this sheet of ice the fishes came in great numbers They crossed the delta bar, pushed their way into the narrow mouth of the creek, and fought their way up the swift current of the ice-cold creek

The main run of smelt is at night Kendall[6] has reported runs on dark days in the streams of New England A few smelt always remain in the stream during the day They hang in the dark pools, under bridges, and the projecting banks and ice But most of them returned to the lake in the morning as soon as it was light. At this time herring-gulls gathered in great numbers to feed upon them

At night on April 17, 1923, just after the sun had set, the fishes began to emerge from the lake, a little cautiously at first and in no great numbers. They headed into the current as it became noticeable at the mouth of the creek and then worked their way towards the mouth The smelt is not a strong stream fish and it was with considerable effort that it made its way against the current An effort was made to avoid the swift current and refuge was often taken behind logs, rocks, vegetation and in the deeper pools. The fishes kept quite close to the bottom as long as any bottom was available to them. Their only object seemed to be that of going up the stream as far as they were able They seemed to tire quickly and not many of them ascended more than four hundred feet Up to this point they hung in great shifting masses, exerting themselves only enough to keep from being carried down-stream During the run of 1925 over 700 pounds were taken from a branch of Cold Creek about a mile up the stream. The current was not as swift as in 1923.

Later in the night (2 A.M.) great schools came into the ice-free pool in the lake From this they tried to work their way into the current of the creek. The sand and gravel delta became one mass of fishes, so numerous that little or none of the bottom could be seen The mouth of the creek became so filled that often the upper layer of fishes was forced clear out of the water by the pressure on all sides of them. Many were unable to get into the stream at all, and much spawn was deposited on the gravel-bottom pool of the lake Misinterpretation of orders in 1925 caused the guard to try to hold the fishes in the stream until 7 A M , some time after daylight, but they crowded about the screen so thickly that a dam was formed which flooded the creek and almost washed out the bridge

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[6] "Fishes and Fishing in Sunapee Lake," *Rept U. S Comm Fish.*, 1912, pp 1-96

Data on the light and current reaction, and on the spawning habit, were obtained at this time (1923) both at the inlet stream and at the outlet. These are presented under various heads as follows

## V LIGHT REACTION

It was noted at once that the fishes were quite sensitive to light. The run is at night and most of the fishes return to deep water during the day or hide under the banks and bridges They are guided to the stream by a reaction to the current, which will be considered later.

With a strong light it was possible to watch the spawning fishes on the bottom of the creek It was soon noted that they would avoid the lighted area of the creek bottom When the light was flashed, those within the lighted area quickly left and very soon the area was vacant. In this way it was possible to drive the fishes in any direction by the change of the light. This observation of 1923 was used by the game warden in 1925 and the entrance of the smelt into the stream was controlled very readily by the use of a light. The escape from the lighted area was accomplished in two ways. Most frequently the fishes merely relaxed and allowed the current to carry them out of the lighted area down-stream to some dark water below, but they also would at times make a sudden dart ahead into the dark water This last reaction was made only when the dark water was just a short distance ahead. When the light was held at the mouth of the stream and directed towards the lake pool a large part of the run could be stopped, many of the fishes retreating under the ice The run is stopped when the daylight causes this reaction and most of the fishes return to the lake by the dropping-back reaction followed by a retreat In this dropping back they usually go tail first down the stream, a phenomenon very perplexing to the many fishermen who in 1925 were able to witness it, when the smelt were held by a screen in the stream long after daylight They are thus left in the dark waters, under the bridges, overhanging banks of ice and snow, or they are carried back into the lake As the run reached its height the fishes became less reactive to the light and more remained in the stream in the daytime

Fish culturists have found that the light is harmful to the eggs of smelt and for the best results they use a room much darker than is usual for hatchery purposes This reaction to the light has important relations to the regulation for their protection or control

## VI. The Reaction to Current

The ripe fishes at Crystal Lake seek out any pool of water free from ice along the shore of the lake They remain at any opening where there is a current, regardless of the direction of this current This reaction is clearly indicated by their presence in some numbers at the outlet of Crystal Lake As well shown in the photograph (Plate XXV, Fig. 2), conditions here were almost identical with those of the inlet stream except for the direction of the current. Fishes found here were all headed upstream. Some of them worked their way back into the lake It is certain that these fishes came from Crystal Lake, since the dam is of such construction as to render it impassible to smelt. Smelt were found as far as one-half mile down-stream. All of these were probably from the lake, since there were several miles of swift flood water between them and Lake Michigan.

Only mature fishes were found in the pool or in the breeding run The one-year-old fishes were missing. It would seem that this reaction to the current is linked with the maturing of the germ cells The older fishes do not have the reaction to current developed until the germ cells are mature The young immature fish likely behave in the same manner as the unripe adults and hence do not appear in the spawning run

This reaction to the current is important in relation to the increase in their range The normal up-stream spawning reaction has little effect on the increase in range, except in rare cases to populate up-stream lakes On the other hand the tendency to come to any pool with a current has a far reaching effect on their increase of range Fishes coming to the outlet stream at night and staying in the current until daylight, when disturbed by the light or confused or fatigued by the current, have a way of relaxing themselves and later drifting with the current, usually tail first, until protection of the dark water is found Thus the down-stream migration is more important from the standpoint of dispersal than the normal up-stream migration The adults of this down-stream migration enter Lake Michigan, as also do the young hatched in the outlet stream The normal up-stream migration only carries them back into Crystal Lake The adults and fry of a normal up-stream spawning migration ordinarily return to the same lake unless there is an up-stream lake a very short distance away. Both of these types of migration will, no doubt, play a part in the further distribution of smelt Since it seems to live a pelagic life in the lake, it must soon be distributed to all parts of any lake it reaches As indicated under the discussion of its distribution, it is now quite abundant in the northern part of Lake Michigan, and the way is open for its introduction into Lake Superior through Trout Lake.

## VII THE SPAWNING HABIT OF THE SMELT

The smelt is the first species of fish to spawn at Crystal Lake. For this reason the eggs and early fry escape being destroyed by other fish which are largely inactive at this season.

Although the smelt has been reared in hatcheries, its spawning habit has not been well understood Kendall[7] has reported a few inconclusive observations upon it Various attempts have been made to effect artificial impregnation, but the best results have been obtained by the use of the natural spawn or from fishes induced to lay their eggs under more favorable conditions for hatching At Crystal Lake in 1923 conditions were ideal for the observation of the spawning activity of the smelt, and what seems to be an explanation of it was obtained

When the fishes enter the stream the eggs and sperm are ripe and the breeding fishes are in a running condition The slightest pressure on the body forces the fishes to yield the eggs or sperm. In this running condition they enter the stream and come in contact with one another and force their way up the creek over the gravel bottom Both sexes are present in these crowded schools of fishes At times a few would become detached from the main group These were watched for spawning activities. The males may be distinguished from the females in many cases Most of the smaller ones are males while the majority of the very large ones are females. Wherever two fishes of this difference in size were discovered together, the activity was watched and afterwards an attempt to catch them in the hands was made to verify the sex determination The males may be distinguished from the females at breeding time by the fact that they are covered with fine pearl tubercles which make their entire body feel like sandpaper. The females are smooth.

Apparently clean gravel was always covered with eggs after a pair had passed over it. Sometimes the bodies of the male and the female would vibrate together. Often this action was little more than the natural motion of the fishes in the stream The caudal portions of smelt are always in motion when they are in the current and all of the schools are thus favorable places for this action to occur indeterminately with the mixed fishes Certainly the stream was too dark for one fish to see another What sex recognition there is must come through the difference in the reaction and the feeling. The fishes would be able to discriminate between the contact of two rough or two smooth bodies or the proper one of smooth and rough

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[7] *Ibid.*, p 77

It is likely that the main spawning takes place as a result of the crowding together of the two sexes when they are in a running condition. The close contact, over the gravel bottom, of the fishes with the spawn running provides an excellent chance for the eggs to be fertilized Eggs were found up and down the stream wherever the fishes had been running the night before Many were found even in the lake, where the fishes were not able to make their way into the creek.

As has been indicated the main spawning ground of the smelt is in the streams, but they also spawn on the gravel delta in the lake or in any pool with a current Kendall in his report states that they spawn on the wind-swept shores or even in lakes without sand shores

## VIII FOOD RELATIONS OF THE SMELT

At Crystal Lake a large number of smelt are taken through the ice with hook and line The lake shiner, *Notropis atherinoides*, is used for bait About twenty smelt caught in this way showed only this bait as stomach content. One specimen contained in its stomach only a single crustacean (Pontoporeia) This would indicate that the smelt does feed during the winter, but to what extent will have to be determined from specimens caught without the use of bait

Fishes on the spawning ground eat but very little. Dr Jan Metzelaar examined 110 smelt collected by the writer from Cold Creek, Beulah, Michigan Most of these were empty but a few contained, in insignificant number, smelt eggs and the debris to which the eggs were attached

Dr. Metzelaar examined the stomachs of 147 smelt taken at Crystal Lake by the writer about September 1 Of these, 20 were totally empty Three contained young rock-bass, 78, the certainly identifiable remains of the lake-shiner, and 35 more, fish remains probably of this species, 25 contained insect larvae or pupae, either midges (Chironomidae), or may-flies (Hexagenia). By volume-percentage the food was as follows

| FOOD | PERCENTAGE |
|---|---|
| Lake shiner, *Notropis atherinoides* | 41 7 |
| Fish remains, probably lake-shiner | 55 6 |
| Rock-bass, *Ambloplites rupestris* | 1 0 |
| Larvae and pupae of midges, Chironomids | 0 6 |
| Larvae of may-flies, Hexagenia | 0 7 |
| Pupal may-flies, Hexagenia | 0 4 |
| Total | 100 0 |

From this it is evident that in summer the adult smelt of Crystal Lake feeds almost entirely (97 3 per cent) on the lake-shiner, a species of minnow which at this season of the year swims about in very large compact schools near the surface, over deep water The adult fishes do not at this season prey to any degree on game fish Furthermore they do not seriously compete at this time with other fishes for food, since, as is shown below, the other fishes do not feed on this shiner

The food of the perch (*Perca flavescens*) in Crystal Lake as determined from forty-seven specimens taken at the same time and in the same net set as the smelt reported above, that is September 1, consisted of insects, 59 per cent, most of which were the larvae and pupae of midges, and crustaceans of various kinds, 41 per cent.

The food of the spot-tailed minnows (*Notropis hudsonius*), taken likewise in the same net, was found to be the same as that of the perch, while those from the shoals were feeding almost entirely on adult insects No data are available as to the feeding habits of the adult fishes during the late spring and early summer. As yet nothing is known about the young fish of the one-year-old groups. Kendall[8] has found that the small smelt of the New England lakes feed upon crustaceans, and it is likely that the young fishes have similar feeding habits. If such is the case they would form rather important competitors of the perch of Crystal Lake.

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[8] *Loc cit.*

The feeding habits of the adults during the late summer show that the smelt at this time is not replacing the other food fishes, but that it is an actual addition to the native fauna But since nothing is as yet known of the food habits of the young fishes, only additional study can determine the point

The specimen of smelt obtained from Lake Michigan contained one fish which Mr Hubbs identified as a young specimen of the lake-herring (or of some other species of the whitefish family) and a crustacean, *Mysis relicta*, which he has shown [9] forms the chief food of the deep-water species of whitefish, chubs, and the like

In view of the known habit of smelt in feeding near the surface at Crystal Lake, and of the well-indicated possibility that the young of the whitefish have the same pelagic habit as that of the lake-shiner, *Notropis atherinoides*, the possible food-relation of smelt with these important food fish in the Great Lakes is apparent

## IX THE GROWTH OF SMELT

Much can be told of the age and growth of smelt from a study of the specimens taken at Crystal Lake The scales can be used for the determination of their age Mastermann [10] has made a study of the European smelt from the scales Only the general outline of the growth will be presented here, since a more detailed study of the material has not yet been completed.

The scales of smelt (Pls. XXVI, XXVII) show very clear year marks (annuli). They are very thin and have widely spaced ridges. Most of the scale is exposed and in this field the annulus shows very plainly Since smelt are hatched in early spring and the specimens referred to were taken at this time of the year, each annulus represents just a year of growth The annulus is formed when growth starts in the spring. The new scale-growth is developed without reference to, and in discord with, the pattern of the older growth of scale Well-defined length-groups, not yet fully worked out, are noticeable These coincide with the groups established on the basis of scale determinations.

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[9] R. E. Coker, *Rept U S. Comm Fish*, Appendix 8, p 13, 1921 (1922)

[10] "Report on Investigations upon the Smelt (*Osmerus eperlanus*) with Special Reference to Age Determination by Study of Scales and Its Bearing upon Sexual Maturity," *Board of Agriculture and Fisheries Fisheries Investigation* (London), Series I, 1 (1913) 113–126.

No one-year-old fish have as yet been taken, consequently only an estimate, based on scale proportion, can be made of the size of smelt at the end of their first year Scale proportions indicate that the smelt is about three or four inches in length at this time. It continues to grow at a rapid rate throughout the second summer and by the time it matures (at the end of the second year) it has reached a size of from six to eight inches The smallest of the two-year sizes so far examined was six and one-half inches in total length (see Pl XXVI, Fig. 1) and the largest one seven and one-half inches The three-year-old fishes reach a size up to nine and the four up to ten inches in total length (see Pl XXVI, Fig 2), and the five-year-old fishes (see Pl. XXVII) are from ten and three-quarters inches to twelve inches long No six-year-old fishes have been examined, but the reports of fishes fourteen inches long indicate that smelt may live to be six years old.

It is also evident from the scales that the smelt does not start to grow until after it spawns and that it does not grow during the winter period

As Kendall has shown, there are at least two 'types'[11] of smelt in the lakes of New England. One of these matures at a much smaller size than the other and it has corresponding differences in feeding habits. As has been shown above, the one introduced into Crystal Lake matures at a large size and reaches a size as large as that reported from the eastern lakes and from salt water Some of the smaller races of smelt mature at a size of about three inches and never reach a size of over six inches. It is therefore apparent that it is the fast-growing type that has been introduced into the Great Lakes. This form is the one best fitted for commercial purposes, not the slow-growing type sometimes recommended as food for the land-locked salmon The latter purpose of course was the one for which it was introduced.

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[11] Carl L Hubbs has discussed the taxonomic status of these landlocked types of smelt and of the Atlantic species in his "Revision of the Osmerid Fishes of the North Pacific," *Proc Biol. Soc. Wash.*, 38. 49–56. 1925.

Some data on the weight-increase has been obtained. At seven and three-quarters inches the fish weighs 1 5 ounces This is about the average two-year-old size. The one-year-old fishes would probably weigh about 0 15 ounces The three-year-old fishes weighed from 2 0 ounces when eight and one-fourth inches long to 3 0 ounces when nine and one-half inches long Those of larger size, about eleven inches, weigh about 5 0 ounces Much additional data are needed to establish the normal weight-increase of smelt

## X THE AGE OF THE SMELT AT SPAWNING

Smelt breeds in the early spring at the end of its second year Evidence of this is found in the scales (see Pl XXVI, Fig 1), since the smallest breeding fishes always have two growing seasons indicated on the scales The first winter is shown by a clear annulus, the other winter edge of the scale is present at the very margin in early spring The annulus is not developed until the spring growth starts after spawning Also when smelt eggs were planted in certain eastern lakes a breeding-run occurred two years later Mastermann has found that the European smelt also breeds at the end of the second year

The effort made at the time of the spawning-run leaves a mark on the scale of the smelt. The lateral edge of the scale is torn and broken at this time This condition will be noticed on the outer edge of all the scales taken from breeding fishes of various ages. These breaks are rebuilt when the scale starts its spring growth and completes the annulus. This spawning annulus is very well shown in the second annulus of Figure 2, Plate XXVI. The first annulus of the spring when the fishes did not spawn is regular A careful study of numerous scales of three- and four-year-old fishes shows that every annulus except the first one has undergone some rebuilding at one point or another. From this evidence it is certain that the smelt breeds at the end of its second year and every year after until its death The presence of different age-groups in the spawning-run also lends support to this conclusion This spawning annulus is comparable to that established for the Atlantic salmon, a fish which makes a spawning-run.

## SUMMARY

The smelt has become completely established in Crystal Lake, Benzie County, Michigan, by planting from Green Lake, Maine Large breeding-runs in and about Cold Creek at Beulah have occurred every spring since 1919 Smelt is also present in Lake Michigan and in Trout and Howe lakes of northern Michigan

Spawning takes place at Crystal Lake before the ice breaks up in the lake as a whole The fishes ascend small streams at night, returning to the lake during the day Spawning fishes avoid the light by a 'dropping back' reaction. They seek out a current and orient themselves against it, regardless of the direction of the current They are being distributed to Lake Michigan by this reaction, which directs them to the outlet stream down which they drift tail first at daylight. About 96,000 fishes entered Cold Creek during the spawning-run of 1925. An examination of the scales showed that the breeding runs are composed of two-, three-, four- and five-year-old fishes. Smelt breeds at the end of its second winter, and every year after that, as indicated by the spawning annuli Growth is very rapid for the first two years, the period of immaturity, after which it falls off noticeably

The two-, three- and four-year fishes at Crystal Lake in summer feed mostly (97.3 per cent) on the lake-shiner One specimen from Lake Michigan was feeding on the young of the lake-herring and on the crustacean, *Mysis relicta*, known to be the food of the deep-water whitefish

The spread of this introduced fish is of great scientific and economic interest, and further study of many of the points presented here will be undertaken.

This study of smelt in the Great Lakes is a part of the biological work supported by the State Department of Conservation of Michigan The writer is delighted to acknowledge this assistance and also that of the Museum of Zoology of the University of Michigan.

College of the City of Detroit
Detroit, Michigan

## EXPLANATION OF PLATES

### PLATE XXIV

A two-year-old, breeding, male smelt from Crystal Lake (life size)

### PLATE XXV

FIG 1 The upper spawning ground of smelt in Cold Creek, Beulah, Michigan

FIG 2 The outlet of Crystal Lake, East Betsie River, by which smelt are reaching Lake Michigan, and in which some spawn

FIG 3 The mouth of Cold Creek, Crystal Lake, reached by the smelt that come to the ice-free pool in the lake

### PLATE XXVI

FIG 1 The scale of the smallest breeding smelt Two years of growth are indicated The first winter is indicated by the well-formed annulus, the scale was taken at the end of the second winter

FIG 2 The scale of a breeding smelt, showing two annuli and three years of growth Spawning marks are indicated for the second and third years.

### PLATE XXVII

The scale of a breeding smelt showing four annuli and indicating five years of growth Spawning marks are present in the second, third and fourth years The numbers on the Plate indicate the growth by years

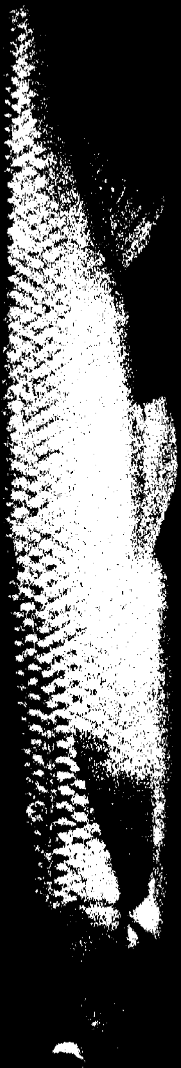

FIG. 1

# THE MAMMAL FAUNA OF A WOODED LOT IN SOUTHERN MICHIGAN

CHARLES M. DAVIS, JR.

DURING the months of March, April and May of 1924, a survey was made of the mammal fauna of a somewhat swampy wooded lot of eighty acres, located in the southeast quarter of Section 27, Scio Township, Washtenaw County, Michigan. This lot is a typical oak-maple-hickory hardwood of second-growth trees. A few large old white oaks are probably from the original stand. Parts of the woods are low and in the spring and early summer are covered with pools of water. The largest of these, of which there are several throughout the woods, is perhaps an acre in extent. They drain away in the late summer, but last long enough to allow the growth of a marginal thicket of dogwood, buttonbush and the like.

The stand is fairly dense and consists of the following species, which are arranged in the approximate order of their frequency:

Red oak (*Quercus rubra borealis*)
White oak (*Quercus alba*)
Red maple (*Acer rubrum*)
Shagbark hickory (*Carya ovata*)
White ash (*Fraxinus americana*)
Basswood (*Tilia americana*)
Pignut hickory (*Carya glabra*)
Wild red cherry (*Prunus serotina*)
Swamp white oak (*Quercus bicolor*)
Sugar maple (*Acer saccharum*)
White elm (*Ulmus americana*)
Red elm (*Ulmus fulva*)
Red ash (*Fraxinus pennsylvanica*)

The undergrowth consists principally of the following species:

Witch hazel (*Hamamelis virginiana*)
Haselnut (*Corylus americana*)
Greybark dogwood (*Cornus paniculata*)
Red osier dogwood (*Cornus stolonifera*)
Flowering dogwood (*Cornus florida*)
Prickly ash (*Zanthoxylum americanum*)
Ironwood (*Ostyra virginiana*)
Service berry (*Amelanchier canadensis*)
Hop hornbeam (*Carpinus caroliniana*)
Buttonbush (*Cephalanthus occidentalis*)
Sassafras (*Sassafras variifolium*)
Hawthorn (*Crataegus sp.*)
Swamp holly (*Ilex verticillata*)
Arrow-wood (*Viburnum acerifolium*)

The commoner herbs are of the following species.

Sedge (*Carex sp*)
Trillium (*Trillium grandiflorum*)
Mandrake (*Podophyllum peltatum*)
Wild strawberry (*Fragaria virginiana*)
Bishop's cap (*Mitella diphylla*)
Bloodroot (*Sanguinaria canadensis*)
Bedstraw (*Galium boreale*)
Violet (*Viola sp*)
Bittercress (*Cardamine douglassii*)
Wild raspberry (*Rubus occidentalis*)
Adder's-tongue (*Erythronium americanum*)

Considerable reproduction of the following species was noted. *Acer rubrum, Fraxinus americana, Tilia americana, Quercus alba, Carya cordiformis, Quercus rubra*

Twelve species of mammals were identified as being present in the woods at the present time Ten of these were taken or observed by the writer, and two are based on reliable reports of capture within the previous year

A list of the mammals follows

PEROMYSCUS LEUCOPUS NOVEBORACENSIS (Fisch). Northern White-footed Deer Mouse — This was by far the most plentiful mammal About twenty specimens were taken near logs or stumps It is almost entirely nocturnal but one was seen at about 3 30 P M., on a very cloudy afternoon The shells of acorns were often seen around the runways and holes where Peromyscus was taken A pair of this species taken from a wooded lot not far away produced a litter of five young on the 19th of April, two days after capture. All of the young died within a few days Three more litters were produced approximately on June 5, August 1 and September 15 The female died about the first of October

BLARINA BREVICAUDA TALPOIDES (Say) Short-tailed Shrew — Five specimens were taken on successive nights, March 20 to 24 In April, May and June the fresh remains of snails were found along the runways used by Blarina. These had probably been eaten by Blarina, since the shells were similar to those mentioned by Shull.[1] These remains were identified by Mr W G Clench, of the Museum of Zoölogy,

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[1] *Amer Nat.*, 41 507

University of Michigan, as belonging to the species *Omphalina cuprea* (Raf), *Pyramidula alternata* (Say) and *Polygyra thyroides* (Say)

TAMIAS STRIATUS LYSTERI (Richardson) Northeastern Chipmunk — Three specimens were taken, two on March 26, and another on May 11 The last of these was taken in a hollow stump which was, apparently, a frequent stopping place for a good many mammals. Several other specimens were seen in the woods

SCIURUS CAROLINENSIS LEUCOTIS (Gapper) Northern Grey Squirrel — Two specimens were secured on April 23, and May 14 Both were taken in densely wooded places

SCIURUS HUDSONICUS LOQUAX (Bangs) Southeastern Red Squirrel — Although one was taken on May 15, these squirrels were not plentiful until the last week in May, when several were seen each day The specimen obtained on May 15 had shed about half the winter coat One taken on May 16 was apparently secreting milk, and the mammary glands were very large

MUSTELA NOVEBORACENSIS NOVEBORACENSIS (Emmons) New York Weasel — One specimen was taken on May 14

MARMOTA MONAX RUFESCENS (Howell) Rufescent Woodchuck. — Two specimens were secured on May 11 One was trapped in the hollow of a standing tree into which she had been seen to run The specimen had prominent mammary glands and was very thin The other was a male Neither showed any indications of the autumnal layer of fat.

SYNAPTOMYS COOPERI COOPERI (Baird) Cooper Lemming-Vole — One small light-colored specimen was taken on May 20, on a dry forest floor two hundred yards from water This was apparently a straggler, as no others were taken

SYLVILAGUS FLORIDANUS MEARNSII (Allen) Mearn's Cottontail — Several specimens were seen at various times in the woods, and their droppings were common

MEPHITIS NIGRA (Peale and Beauv). Eastern Skunk. — A good many of this species were taken by a local trapper in this woods during the winter of 1923–24. I saw several carcasses and skulls in a hollow where they had been left by him

PROCYON LOTOR (Linn ) Raccoon — One was reported killed in this woods in the fall of 1923 Some may still exist in this or neighboring woods

SCIURUS NIGER RUFIVENTER (Geoffroy) Fox Squirrel. — No specimens were secured, but the species is frequent here according to local reports They are common all around Ann Arbor

The writer is indebted to Dr Lee R Dice, curator of mammals in the Museum of Zoology, University of Michigan, for constant help and supervision, and to Mr Carl O Erlanson of the Department of Botany, University of Michigan, for help in the determination of the plant names.

UNIVERSITY OF MICHIGAN

# THE PHYLOGENY AND PHYLOGENETIC TENDENCIES OF GYRINIDAE *

MELVILLE H HATCH

THE present paper is a study of the phylogeny and phylogenetic tendencies of the coleopterous family Gyrinidae The author has seen about 30 per cent of the forms described, representing the major groups of species and has studied most of the lesser evolutionary tendencies indicated in the literature, with the exception of Paragyrinus Ochs (1924, p 231). Most of the exotic material was procured from Staudinger and Bang-Haas The data relative to the intergeneric variation of Gyrinidae were secured in the course of a study of the exoskeleton which will be published elsewhere

De Kerherve (1922) and Ochs (1924) make observations, unsupported by detailed considerations, on the phylogenetic history of the Gyrinidae which are more or less at variance with the results of the present study. De Kerherve considers Enhydrus as a recent migrant to South America This same author's insistence upon the relatively late appearance of the Orectochilini is in accord with my own views Ochs, apparently on the basis of its cosmopolitanism, regards Gyrinus as nearest to the primitive type of the family, and places the Gyrininae first, followed by Enhydrinae and Orectochilinae.

The author makes acknowledgment to Professor Paul S Welch under whose direction this study was made, and to Herr Georg Ochs for specimens, especially a paratype of *Orectochilus africanus* Ochs, and for bibliographical aid.

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* A contribution from the Zoölogical Laboratory of the University of Michigan.

## I. PHYLOGENY

Since the days of Le Conte and Horn the Gyrinidae have usually been associated with the Cicindelidae, Carabidae, Haliplidae, Hygrobiidae, Amphizoidae and Dytiscidae to form the series or suborder Adephaga Some authors place the Cupedidae, Rhysodidae and Paussidae in the same series, largely on the basis of wing venation Fowler's (1912, pp 51–52) table of the families may be consulted for a statement of the characters involved There is a tendency in certain quarters to separate the Gyrinidae from this complex Sharp (1899, p 216) writes that they have little or no affinity with other Adephaga, and Fowler (1912, p 50) states that, if they are not to be retained as Adephaga, they must form a suborder of their own Leng (1920, p 26) raises them to the rank of a superfamily which, with the Caraboidea, forms the suborder Adephaga

The first step that one must take in the study of gyrinid affinities is to divest the beetles of their adaptive characters Eyes, antennae, legs and mesosternum must all be left out of consideration These are gyrinid rather than coleopterous structures, a complex of features which have arisen in the process of the beetle's becoming a gyrinid In the light of its non-adaptive characters, it is not impossible to determine its affinities with a fair degree of approximation

In general structure the Gyrinidae are adephagous Despite the great superficial modification of those parts, both antennae and tarsi retain the primitive number of segments. The second ventral segment of the abdomen is visible The propleural suture is present. Above all, the wing retains the areola oblonga or oblongum, a feature that is very characteristic of the Adephaga. Horn (1881, p. 94) based his primary division of the series on the presence or absence of the antecoxal suture. The Gyrinidae and Dytiscidae alone lack this structure A further character of possible significance is the retention of the tip of of Cu in the primitive gyrinid It is likewise present in species of Haliplidae, Hygrobiidae, Amphizoidae and Dytiscidae, and may be evidence of the validity of Handlirsch's superfamily

Hydrocantharini (1923, p 550), which was erected to include these families and the Gyrinidae

When the Dytiscidae and Gyrinidae are compared in detail, practically nothing is found in the latter that cannot be derived from the former The homologies that possibly exist between the divided gyrinid eye and the upper and lower lobes of the eye of Colymbitini will be pointed out in another paper In the trophi it is probable that the parts in the gyrinid represent a condition of severe simplicity which can be interpreted best as a reduction A similar though less strongly marked tendency in the same direction is manifested in the dytiscid trophi Such differences as there are between the two are evidence of greater derivativeness in the Gyrinidae The two segments of the galea have been fused into one The single infrabrustia of the mandible in Dytiscus is reduced to an impressed line in the gyrinid In the labium, the loosely constructed stipulae with their distinct palpigers in Dytiscus have become the heavily chitinized stipulae of the Gyrinidae with the palpigers fused with and hardly distinct from the rest of the structure The abdomen of Gyrinidae is eight-segmented In Dytiscus the eighth segment is more complicated, more primitive, than in the Gyrinidae, being split ventrad along the meson Within the eighth segment a rudimentary ninth segment is to be found

The genitalia offer the most serious difficulty to the postulation of a dytiscoid ancestry for the Gyrinidae The female genitalia of the two are profoundly dissimilar. The difficulty in regard to the male genitalia arises if they are considered primitive. Like the trophi and the terminal portions of the abdomen, the genitalia appear simplified It is entirely possible that Sharp and Muir (1912) may have mistaken a simplified for a primitive condition At any rate, until more evidence can be obtained on this subject, it is best to follow the weight of evidence in favor of a dytiscoid ancestry for the Gyrinidae Granted a dytiscoid ancestry, it is not unreasonable to suppose that a good portion of the general aquatic adaptations of the gyrinid body, as shape, contour and the coadaptation of parts, is truly homologous with dytiscoid structure

No scientific postulation can be more certain than that the Gyrinidae were derived from some more generalized, non-gyrinid, non-surface-dwelling, coleopterous ancestor If the dytiscoid ancestry be accepted, the evolution of the gyrinoid type involves the modification of some pond beetle ancestor with air-breathing larvae to form a race of beetles highly adapted in the imago to life on the surface of the water and in the larval stage to life in the water independent of the surface

It is possible to arrive at a formula that will do justice to the findings of the science of heredity and to the facts of adaptation by supposing that the environment preserves favorable variations That new types, as the Gyrinidae, have come into being as the result of a single change from some other form is not likely. It is much more probable that they began in a feeble tentative way to take up life on the surface of the water They found a high degree of freedom from competition in this habitat and were favored, so that, when, as a result of subsequent changes, they became increasingly adapted to it, they were still more favored In this way it is still possible to speak of the direct influence of the environment, for nothing can be surer than that the gyrinids would never have developed in the absence of a surface habitat

*Paleontological evidence* — Handlirsch (1906–1908, pp 446–449) rejects as uncertain the customary ascription of the Mesozoic fossils to the Gyrinidae Cenozoic species have been described as follows GYRINUS, Oligocene, Miocene, Pleistocene of Europe, recent species from interglacial of Europe and North America, PALAEOGYRINUS, Oligocene of Europe; GYRINOIDES, Oligocene (Baltic Amber) of Europe, DINEUTUS, Upper Miocene of Europe

The remoteness of the upper eye from the margin of the head together with the general habitus is a character that will diagnose Gyrinidae and is applicable to fossils. Handlirsch can hardly have appreciated this, or he would not have rejected *Anagyrinus atavus* Heer (Lower Lias of Switzerland) as a gyrinid The figure (Handlirsch, T XLI, Fig 41, Heer, 1876, Vol. I, Pl VIII, Fig. 18) shows the dorsum of a beetle of general gyrinid facies, about 3 5 mm long (4 mm. in Handlirsch) with the eyes distinctly removed from the margins of the head and with a distinct scutellum. Heer's three species of Gyrinites with "the eyes reaching the margin of the head" (1876, p 90) are probably not gyrinids *Dineutus longiventris* Heer (1876, Vol II, Fig 281, p 38), length 8 3 mm, from the Swiss Upper Miocene, which likewise has the eye completely removed from the margin of the head and the scutellum invisible, is probably a valid gyrinid Figures or descriptions of the other Cenozoic Gyrinidae are not at hand. In general, however, Gyrinus or gyrinoid types are to be expected in the Holarctic area during Cenozoic time

The presence of a definite gyrinid fossil in the Lower Jurassic and the absence of all beetle remains in the pre-Mesozoic place the origin of the Gyrinidae fairly definitely in Triassic time

The structure of the two species indicated above is too scantily known to warrant any very significant conclusions. Size, shape and the presence of a scutellum place Anagyrinus with the Gyrinini, in fact there is no positive reason for not considering it a true Gyrinus It must be remembered in connection with the small size of this insect that the Lias was a time of unfavorable climates and small insects Size and the absence of a scutellum argue in favor of the correctness of the assignment to Dineutus of the upper Miocene species Heer (1876, Vol. II, p. 145) claims that the climate of the Miocene fauna and flora of Switzerland is "sufficiently explained by adding 9 degrees Cent (or 16 2 degrees Fahr.) to the present temperature" Nine degrees Centigrade is just about the average annual difference in temperature today between Switzerland and those parts of Syria and Egypt inhabited by *Dineutus subspinosus* Klug It is possible that, under the stimulus of milder climatic conditions, Dineutus was able to extend its range from its Ethiopian center and penetrate farther to the north in this region than it can at the present.

INTERGENERIC VARIATION OF GYRINIDAE

| | Enhydrus | Dineutus | Porrhorhynchus | Androgyrus | Macrogyrus | Orectochilus | Orectogyrus | Gyretes | Aulonogyrus | Gyrinus |
|---|---|---|---|---|---|---|---|---|---|---|
| Corpotentorium | P | P | P | P | P | D | D | D | D | D |
| Brachycephalization | P | P | P | P | P | P | P | D | P | D |
| Eyes | P | P | P | P | P | P | D | D | P | D |
| Antacaval ridge | P | P | P | P | P | P | P | P | D | D |
| Exoculata | P | P | P | P | P | D | D | D | P | P |
| Antacava | P | P | P | P | P | D | D | D | P | P |
| Pseudofrontal ridge | P | P | P | P | P | P | D | D | P | P |
| Antenna | D | D | ½D | P | ½D | P | D | P | P | P |
| Lobe of mandible | P | P | P | P | P | D | D | D | ⅔D | ⅔D |
| Galea of maxilla | D | D | D | D | D | D | D | D | P | P |
| Epinotum | P | P | P | P | P | P | P | P | P | D |
| Prosternum | P | P | P | P | P | D | D | D | P | P |
| Scutellum | P | ½D | D | P | P | P | ¼D | ½D | ¼D | ¼D |
| Mesocoxae | P | ½D | P | P | P | ½D | D | ½D | ½D | ½D |
| Metafurca | P | P | P | P | P | P | P | P | D | P |
| Metacoxae | P | P | P | P | P | D | D | D | ½D | ½D |
| Quitarsomere | P | P | P | P | P | P | P | P | D | P |
| Mesoprephragma | P | ½D | ½D | ½D | ½D | ½D | P | D | D | D |
| Mesoscutum | P | P | D | P | P | P | P | P | P | P |
| Mesonotum | P | P | P | P | P | D | D | D | P | P |
| Dorsal pubescence | P | P | P | P | P | D | D | D | P | P |
| Elytral apex | P | ½D | D | P | D | D | D | D | D | D |
| Metanotum | P | P | P | P | P | P | P | P | D | D |
| Tip of Cu | P | D | D | D | D | P | P | P | D | D |
| Loss of W | P | P | P | D | D | D | D | D | D | D |
| Loss of 3d $A_2$ | P | P | P | P | P | D | D | D | P | P |
| Hairs of abdomen | P | P | P | P | P | D | D | D | P | P |
| Latacoria | P | P | P | P | P | D | D | D | ¼D | ½D |
| Terga | P | P | P | P | P | D | D | D | P | P |
| Sterna | P | P | P | P | P | D | D | D | P | P |
| Trosternasuture | P | ½D | ½D | ½D | ½D | D | D | D | P | ½D |
| Quaprevenplicae | P | P | P | P | P | D | P | D | D | D |
| Genitalia | P | P | P | P | P | D | D | D | ½D | ½D |
| Total | 2D | 5½D | 6½D | 4D | 5½D | 20D | 22¼D | 24D | 12⅔D | $14\frac{5}{12}$D |

## II PHYLOGENETIC TENDENCIES

### 1 *Primitive and Derivative Characters*

The accompanying Table presents the essential data in regard to the intergeneric variation of the Gyrinidae In it the several characters that vary intergenerically to the number of thirty-four have been tabulated. The letter *P* indicates the character in an unmodified or primitive form, *D*, the character in a modified or derivative form The modifications involved are indicated below in the order in which they appear in the table

The corpotentorium may be present (P) or absent (D)

Brachycephalization involves the absence (P) or presence (D) of an antero-posterior compression of the head

'Eyes' refers to the absence (*P*) or presence (*D*) of a forward displacement of the dorsal compound eye

The antacaval ridge may be distant (P) or near (D) the exoculata

The exoculata may be present (P) or exhibit a tendency towards obsolescence

The antacava may (P) or may not (D) fail to attain the frontal ridge

The pseudofrontal ridge, a second ridge above the frontal ridge, may be absent (P) or present (D)

The antenna may have a flagellum with nine segments (P), eight segments (⅓ D), seven segments (⅔ D), or six segments (D)

The lobe of the mandible may (P) or may not (D) fail to display a tendency towards the obsolescence of its proximo-median lobe

The galea of the maxilla may (P) or may not (D) be present

The epinotum may (P) or may not (D) be transversely impressed.

The prosternum may (P) or may not (D) fail to display a cephalad migration of the procoxacavae, which results in the extreme narrowing of the elevated anterior margin of the prosternum

The scutellum may be broadly (P) or narrowly (⅓D) triangular as exposed by the elytra at rest, or covered by the epinotum (⅔D), or with a bilobed posterior margin (D)

The mesocoxae may be distant (P), moderately close (½D), or approximate (D)

The metafurca may (P) or may not (D) fail to have its bifurcated arms fused.

The metacoxae may (P) or may not (D) fail to exhibit a tendency of the anterior margins of the coxae to assume an extremely oblique position, which results in a reduction of the size of the metasternal wings.

The quitarsomere may (P) or may not (D) be separated from the quatarsomere in the meso- and metapods.

The mesoprephragma may be simple (P), bilobed (½D), or bifurcate with long arms (D), or secondarily simple (D)

The mesoscutum may (P) or may not (D) be divided into anterior and posterior areas

The mesonotum may (P) or may not (D) fail to be compressed so that a considerable portion of its surface is forced over onto its cephalic aspect.

'Dorsal pubescence' refers to the absence (P) or presence (D) of at least a marginal area of pubescence on the dorsum

The elytral apex may (P) or may not (D) be evenly rounded In only a few of the species of Dineutus (½D) is the elytral apex not rounded

'Metanotum' refers to the presence (P) or absence (D) of a caudal production of the notopterae

'Tip of Cu' refers to the presence (P) or absence (D) of the tip of the cubitus.

'Loss of W' refers to the presence (P) or absence (D) of the wedge-cell.

'Loss of 3d $A_2$' refers to the presence (P) or absence (D) of the second branch of the third anal vein

'Hairs of abdomen' refers to the absence (P) or presence (D) of a row of hairs on the meson of the caudal abdominal sterna

'Latacoriae' refers to the absence (P) or presence (D) of an increased membranization of the basal latacoriae and the absence (P) or presence (D) of a tendency towards the increased chitinization and loss of the caudal latacoriae

'Terga' refers to the absence (P) or presence (D) of a tendency towards the increased membranization of the basal abdominal terga

The sterna of the caudal abdominal segments may (P) or may not (D) fail to exhibit elongation

The tresternasuture may be present (P) or partially (½D) or almost completely (D) obsolescent.

The quaprevenplicae may be absent (P) or present (D)

The genitalia may have the lateral lobes in both sexes broad and rounded (P), truncate (½D), or narrowed (D)

The validity of the tabulation depends (1) on its completeness, (2) on the certainty with which the characters can be indicated as either primitive or derivative, and (3) on the degree to which the more significant variations have not been overshadowed by the less significant

A few characters have not been tabulated

(1) The degree of expansion of the protarsal segments varies considerably and reaches an extreme in Enhydrus It is possible that this should be indicated as a further derivative character for this genus, but secondary sexual characters are so variable in general that it seemed best to omit reference to them.

(2) It is quite impossible to designate with any degree of certainty the nature of the elytral sculpture of the primitive gyrinid. On the assumption that it was smooth, it would be

necessary to regard all the tribes derivative in respect to elytral sculpture. Attention has been confined to the dorsal pubescence, and its presence in the Orectochilini has been regarded as derivative, its absence in other tribes as primitive.

(3) It has been impossible to decide whether or not the broader more rounded gyrinin wing is to be regarded as primitive or derivative.

(4) Consideration of the variable grooves on the ventral surface of the mandible has been omitted since they are of uncertain significance.

(5) No attempt is made in the Table to indicate the degree of derivativeness suggested by body size. Gyrinidae range in length from 27 mm. (*Porrhorrhynchus landaisi* Rég.) to 3.5 mm. (*Gyretes angustatus* Rég.), which means that the largest gyrinid is approximately two hundred times the volume of the smallest. The data for the genera and certain of the subgenera are given below; the mode is the length most frequently attained by species of the genus: Enhydrus, 11–22 mm., mode 18–22 mm.; Dineutus (*s. str.*), 9.6–23 mm., mode 15 mm.; Cyclinus, 8.5–16 mm., mode 10 mm.; Cyclous, 6.75–16 mm., mode 9 and 12.5 mm.; Spinosodineutes, 7–9 mm., mode 8–8.5 mm.; Porrorrhynchus, 11.5–27 mm., mode 20–21 mm., Androgyrus, 11–18 mm., mode 13 mm., Macrogyrus, 6.5–18 mm., mode 11–12 mm.; Orectochilus, 3.8–13 mm., mode 6 mm., Orectogyrus, 4.5–14 mm., mode 8 mm., Gyretes, 3.5–10 mm., mode 5 mm., Aulonogyrus, 4–10 mm., mode 6 mm., Gyrinus, 3.8–8 mm., mode 5 mm.

If the view that Enhydrus approximates the primitive type is correct, Porrhorrhynchus represents only a slight increase in size, and the general tendency is towards a decrease. Some of the larger species of Orectogyrus apparently represent a secondary increase. In the intrageneric development of Dineutus, Orectochilus and Gyrinus, in the movement from Enhydrus to Dineutus, from Enhydrus through Androgyrus to Macrogyrus, from the Enhydrini to the Orectochilini and Gyrinini, from Orectochilus to Gyretes, from Aulonogyrus to Gyrinus a decrease in size accompanies increased derivativeness. Gyretes and Gyrinus, the genera standing at the ends of the two main lines of development of the family, are the two smallest. The larger species in general inhabit the more tropical regions, the smaller species are distributed quite indiscriminately

The argument for considering the various characters in the Table as primitive or derivative may be formulated under six heads

(1) The most fundamental assumption is that those conditions present in a considerable number of other Coleoptera are to be considered generalized when present in the Gyrinidae and that departures from this are to be considered as derivative. The following characters are considered primitive on these grounds presence of a corpotentorium, presence of a galea on the maxilla, and eleven-jointed antenna, a complete tresternasuture, absence of a row of hairs on the meson of the terminal abdominal sterna, absence of a pseudofrontal ridge (as in Dytiscidae), and a simply rounded elytron On the same grounds a mesoscutellum exposed by the epinotum has been considered more primitive than one covered by the epinotum and the departure of the scutellum from the triangular form has been considered derivative Because the metascutellum as a rule attains the anterior margin of the metanotum in Coleoptera, it was felt that its failure to do so in the Gyrinini indicated a derivative condition.

(2) It has been assumed that within a small group like the Gyrinidae the loss of a structure is a more frequent occurrence than its gain. In general where structures, sutures, wing-veins, antennal segments, etc , have been found to be absent or more reduced in one genus than in another, it has been assumed that the condition of absence or reduction is the more derivative.

(3) Superficial characters are present in some of the genera that are of such aberrant or unusual occurrence in Coleoptera that it was felt that it was quite safe to consider them derivative Such are the rows of hairs on the meson of the caudal abdominal terga, the marginal pubescence of the dorsum, the fused arms of the metafurca, the quaprevenplicae, and the pseudofrontal ridge found in one or another of the genera

(4) Variations indicating a tendency in the direction of an

antero-posterior compression of sclerites are likewise interpreted as derivative This is a well-known tendency among aquatic insects and it is not surprising that it should be manifested in the Gyrinidae The shortening of the head, shifting of the eyes, shifting of the antacava relative to its surrounding ridges, shifting of the procoxacavae, compression of the mesonotum, and marked shifting of the metacoxae and compression of the metasternum are all to be interpreted as manifestations of this process

(5) Correlated with their life on running water, the Orectochilini possess an extremely attenuated elongate body It is assumed that the migration was from ponds to streams and not vice versa, and, consequently, that such characters as are closely correlated with the attenuated body are to be regarded as derivative In some cases the connection is quite obvious, for example in the elongate terminal abdominal segments, the approximate mesocoxae, the oblique metacoxae, and the narrow mesoscutellum It is not quite as obvious why the mandibles and paired lateral lobes of the genitalia should show the same tendency. The latter may, perhaps, be correlated with the narrower caudal abdominal segments

(6) Characters have been indicated as primitive in a few instances when it was felt that they approximated a more or less hypothetical type The determination of primitiveness is much less certain in these instances, though it is believed that it still possesses a considerable degree of validity. Fortunately the characters in this class are neither numerous nor especially important The tendency towards increased membranization of the basal abdominal terga and latacoriae has been interpreted as derivative It is supposed that it may be indicative of a general tendency in the Coleoptera With increasing dependency upon the elytra the need for hard basal terga and latacoriae became less and less Certainly somewhere in the ancestry of the beetles a form occurred with membranous meso-wings and relatively hard terga and latacoriae. Furthermore, the tendency of the mesoprephragma in the Gyrinidae to develop a pair of long arms has been regarded as derivative, a simple bilobed condition as more or less intermediate, and a simple condition as

primitive, except in Gyretes, in which the simple lobe extends in an elongate arm and is regarded as secondarily simplified and derivative Finally, the slightly truncate genital lobes in the Gyrinini are regarded as more derivative than the simply rounded condition in the Enhydrini

It will be noticed that three of the characters listed in the Table refer to reduction of wing veins, eight characters, five of them in the head, refer to antero-posterior compression, and five to the process of attenuation and elongation.

## 2 *Tendencies of Tribes and Subfamilies*

As inspection of the Table of characters reveals that there are three distinct groups of genera as regards degree of derivativeness, represented respectively by the figures $2–5\frac{1}{2}$, 20–24, and $12\frac{1}{2}–14\frac{3}{8}$. These correspond to the three gyrinid tribes designated by Régimbart (1882–1907) as Enhydrini, Orectochilini and Gyrinini Ahlwarth in Pars 21 of the *Coleopterorum Catalogus* (1910) raised the rank of these tribes to subfamilies, and is followed in this by Winkler (1924) and Ochs (1924), but not by Leng (1920) or Handlirsch (1923). The tribes may be defined as follows

Enhydrini corpotentorium present, galea absent; elytra with nine striae which are frequently obsolete, dorsal eye never anterior to ventral eye, antacaval ridge moderately distant from exoculata which is distinct; frontal ridge distant from dorsal margin of antacava, antennae 8–11-segmented, posterior median lobe of mandible distinct; procoxacavae distant from anterior margin of prosternum, anterior margin of metacoxa never extremely oblique, metasternal wings in form of broad triangle; portion of metacoxae mesad of coxacarina greater than portion laterad; mesal portion of mesonotum visible on dorsal aspect anterior to mesoscutulis; metascutulis attaining cephalic margin of metanotum, notopterae produced caudad at caudal margin of metanotum, wing elongate; tip of Cu typically present, absent in some of the derivative genera; wedge-cell and 3d $A_2$ present, caudal segments not elongate, without a row of hairs on meson below; genital lobes broad and rounded caudad.

Orectochilini. corpotentorium and galea absent, elytra unsculptured; at least the lateral margins of dorsum pubescent, antacaval ridge moderately distant from exoculata which is indistinct; frontal ridge identical with dorsal margin of antacava, antennae 8–11–segmented, posterior median lobe of mandible indistinct, procoxacavae close to anterior margin of prosternum, anterior margin of metacoxae extremely oblique, portion of metacoxae mesad of coxacarina much narrower than portion laterad, mesal portion of mesonotum invisible on dorsal aspect anterior to mesoscutulis, metascutulis attaining cephalic margin of metanotum, notopterae produced caudad at caudal margin of metanotum, wing elongate; tip of Cu present, wedge-cell and 3d $A_2$ absent, terminal abdominal segments elongate with a row of hairs on meson of venter, basal abdominal terga and latacoriae coriaceous, tresternasuture obsolete, genital lobes narrow and elongate.

Gyrinini corpotentorium absent, galea present, elytra with eleven striae, the discal ones of which are sometimes obsolete, antacaval ridge close to exoculata which is distant, frontal ridge distant from dorsal margin of antacava, antennae 9–segmented, posterior median lobe of mandible distinct, precoxacavae distant from anterior margin of prosternum, anterior margin of metacoxae oblique, metasternal wings narrow, portion of metacoxa mesad to coxacarina narrower than portion laterad; *mesal portion of mesonotum visible on dorsal aspect anterior to* mesoscutulis, which is always in part exposed by the epinotum, metascutulis not attaining cephalic margin of metanotum, notopterae not produced caudad at caudal margin of metanotum, mesoprephragma produced in pair of long arms, wing shorter and more rounded caudad; tip of Cu and wedge-cell absent, 3d $A_2$ present, caudal abdominal segments not elongate, without a row of hairs on meson below; genital lobes subtruncate caudad

While these tribes represent the lines of cleavage that stand out most clearly in both a structural and geographical sense, the Enhydrini and Orectochilini are probably more closely related to each other than is either tribe to the Gyrinini. The most important variations to be considered are the loss of the galea in the Enhydrini and Orectochilini and the loss of the corpotentorium in the Orectochilini and Gyrinini The loss in both cases is probably a derivative character, so that neither Enhydrini nor Gyrinini can be derived from the other, but must represent divergent tendencies They must both be derived from some hypothetical gyrinid possessing both corpotentorium and galea

The Orectochilini are derivative as regards both galea and corpotentorium They are an adaptation of the pond-inhabiting gyrinid to running water Their structure involves a considerable compression of sclerites in the thoracic region as well as a general attenuation of the body and an elongation that is effected chiefly by a lengthening of the terminal abdominal segments Two new characters are present, their dorsal pubescence and the row of hairs on the meson of the terminal abdominal sterna The proof of the close relationship of the Enhydrini and Orectochilini lies in the repeated occurrence of similar primitive features in the two groups, as the retention of the tip of Cu in Enhydrus and the Orectochilini, the retention of the relatively simple mesoprephragma, metanotum, and a wide space between the antacaval ridge and the exoculata The Orectochilini and the Gyrinini agree in the loss of the corpotentorium and also to the extent that their antero-posterior compression has resulted in a somewhat similar modification of the metacoxae and the metasternal wings Both these are derivative characters, and while importance must be attached to them, the possession of many primitive characters in common by Orectochilini and Enhydrini outweighs them in my opinion The Orectochilini are a highly derivative group, much more so than the Gyrinini, but their specialization has been in an entirely different direction, and their affinities are nearly all with the relatively primitive Enhydrini, especially with Enhydrus, the most primitive genus of the family

In the light of this evidence, it is proposed to unite the Enhydrini and Orectochilini to form a single subfamily, Enhydrinae, and to place the Gyrinini in a second subfamily, the Gyrininae This removes the Orectochilini from its traditional place at the end of the gyrinid series, but such is the result of arranging the tribes in accordance with lines of descent rather than according to the static concept of the degree of specialization The two subfamilies may be defined as follows

Enhydrinae galea absent, antacaval ridge moderately distant from exoculata, metascutulis attaining cephalic margin of metanotum, notopterae produced caudad at caudal margin of metanotum, wing elongate, tip of Cu present, though absent in the more derivative genera of Enhydrini

Gyrininae galea present, antacaval ridge close to exoculata, metascutulis not attaining cephalic margin of metanotum, notopterae not produced caudad at caudal margin of metanotum, wing shorter and more rounded caudad, tip of Cu absent

For purposes of identification, the gyrinid tribes may be distinguished according to the following Table

TABLE OF TRIBES OF GYRINIDAE

A$^1$ Dorsal surface entirely glabrous, last abdominal segment rounded without row of hairs on meson below
  B$^1$ Portion of metacoxa laterad of coxacarina less than portion mesad, metasternal wings in form of broad triangle, elytra smooth or with nine striae, length usually over 8 mm 6 5–26 mm Enhydrini
  B$^2$ Portion of metacoxa laterad of coxacarina greater than portion mesad, metasternal wings narrow, elytra with eleven striae, sometimes with discal striae obsolete, length usually under 8 mm 3 75–10 mm Gyrinini
A$^2$ Dorsal surface usually without sculpture, pubescent, at least at margins, last abdominal segment elongate, conical, with row of hairs on meson below, length usually under 10 mm 3 5–14 mm Orectochilini

Each tribe is, in general, world-wide in distribution. The absence of Orectochilini from Australasia is correlated with the high degree of derivativeness of this group and its consequent late development in geological time Each tribe represents an independent process of migration, dispersion and adaptation to the varying geographical habitats In the case of the Gyrinini and the Enhydrini, the pond situation, with the exception of certain species, has probably been the one occupied, on the one hand by forms with a small size and on the other hand by forms with a large size The Orectochilini represent an adaptation to running water that gave an opportunity for a third dispersion.

## 3 *Enhydrini*

The genera of the Enhydrini may be tabulated as follows:

### TABLE OF GENERA OF ENHYDRINI

$A^1$ Form primitively broad, becoming secondarily narrow in certain species of Dineutus, wedge-cell present between 2d $A_2$ and 3d $A_1$.
  $B^1$ Scutellum visible, tresternasuture complete, elytral striae distinct; flagellum 6–segmented, tip of Cu present, South America — Enhydrus
  $B^2$. Scutellum invisible, tresternasuture incomplete, tip of Cu absent
    $C^1$ Labrum transverse, elytral striae feeble to obsolete, flagellum 6–segmented, caudal margin of scutellum simple — Dineutus
    $C^2$ Labrum triangular, elytra, striae obsolete, flagellum 8–segmented, caudal margin of scutellum bilobed, 11–26 mm long, Indo-Malaysian — Porrhorrhynchus
$A^2$ Form more narrow, wedge-cell and tip of Cu absent, scutellum visible, tresternasuture incomplete, elytral striae feeble
  $B^1$ External elytral angle not prominent, flagellum 9–segmented; South America — Androgyrus
  $B^2$. External elytral angle prominent, flagellum 8–segmented, Australasian — Macrogyrus

There are two quite distinct subtribes of Enhydrini sharply distinguished by bodily form and wing venation. In either case, the most primitive member of the group is found in South America. On the one hand the migration was to Africa and North America; on the other hand, to Australia.

The presence of a complete tresternasuture and of the tip of Cu reveals Enhydrus as the most primitive genus of the tribe. The broad form and simply rounded elytral apex are probably further primitive characters A simply rounded elytral apex almost self-evidently represents a more primitive condition than a sinuate, truncate, or variously spinose one It is the only type from which the other types can be derived Not even the species of Enhydrus possess a perfectly rounded elytral apex, but present faint signs of the emargination which becomes so prominent in other members of the tribe. The broad form is considered primitive in part because it represents a minimum degree of adaptation to life on the surface of the water The distinctly pointed contour that the anterior portion of the body assumes in Porrhorrhynchus and *Dineutus discolor* Aubé and the narrow subcylindrical form of the Orectochilini and *Dineutus angustus* Lec. show the ways in which the primitive form has been modified, especially under the influence of running water. Even the narrowing of the body of Androgyrus and Gyrinini probably represents an increased adaptability to surface conditions If it be supposed that the Gyrinidae came from some quiet water ancestor of dytiscoid habits and form, some clue is provided to the origin of the broad oval form

The moderately large size and distinct elytral striae are further characters that are considered primitive. Those species of Dineutus that most nearly approach Enhydrus in form and in the shape of the elytral apices likewise closely approximate it in size. When striae can be traced at all in the Dineutini, as they can in some species of all the genera except Porrhorrhynchus, they are nine in number. It is more natural to suppose that there is a general tendency to lose the striae than that they have been independently acquired in the several genera.

The flagellum of the antenna possesses only six segments in Enhydrus and Dineutus, which indicates the close relationship of the two. Porrhorrhynchus and Patrus (Orectochilini) in the Malay region and Androgyrus in South America are groups otherwise derivative from Enhydrus, but with from eight to nine segments in the flagellum. Perhaps they are evidence of some preënhydroid group with a nine-segmented flagellum and an extensive distribution

Enhydrus constitutes a group of only four species confined to Panama, northern South America, and Brazil They vary in regard to the shape of the anterior legs of the male, the color of the surface of the body, and the nature of the elytral striae Nothing is recorded concerning their habits

Dineutus and Porrhorrhynchus are distinguished from Enhydrus by three characters, each one of which can be considered a direct derivative of the condition in Enhydrus· (1) the obscuring of the scutellum by the posterior margin of the epinotum, (2) the partial obsolescence of the tresternasuture, and (3) the tendency towards obsolescence of the elytral striae. Dineutus is the less derivative of the two. It is absent from the range of

Enhydrus except in Panama, though it occurs in the geographically adjacent regions of Central America and Ethiopia Elsewhere it occurs in the West Indies, Mexico, United States and southern Canada east of the Rocky Mountains, Canary and Cape Verde Islands, Egypt, Syria, Kashmir, Ceylon and India north to Manchuria, Korea and Japan and southeastward throughout the East Indies, except Solomon Islands, to Australia, Tasmania, New Zealand, New Caledonia and Fiji Islands

This is an illustration of a principle of more or less general application in the Gyrinidae, that closely related groups of species often do not have identical but adjacent centers of dispersal Overlapping is due to migration from separate centers It is natural to suppose that, when a group of animals has established itself in a region, it has been successful in becoming adapted to some situation in that area When the migrants from this original stock enter an adjacent area the effect of isolation and a different environment makes itself felt in the production of a new race, the result of a new situation, a race that is adapted to the new situation and not to the old. In general it may be expected that the habitat occupied in the new region is closely similar to the old, and that the differentiation between the two races is not great It is not at all surprising, then, that the derivative form is unable to reënter and establish itself at all extensively in the territory of its ancestor Increased derivativeness does not necessarily involve improvement. Evolution may take the form of a coincident but divergent process operating upon an originally homogeneous stock in adjacent but isolated or semi-isolated areas Each race will become fitted to its own particular set of conditions and will often be highly successful in keeping out relatives from adjacent regions If one of the races is an improvement upon the other and no barriers prevent, it will extend its range, perhaps exterminate the other race, and obliterate the record.

The species of Dineutus may be divided into four subgeneric groups, as indicated in the Table

## TABLE OF SUBGENERA OF DINEUTUS MACLEAY

$A^1$ Body broad, oval, not narrowed anteriorly, elytral apex usually feebly sinuate at exterior angle (apex bidentate in *D sinuosipennis* Cast ), size usually large, rarely (*D arabicus* Rég and *D perezi* Rég , Arabia) less than 12 mm long, occurs throughout range of genus except West Indies, northern and central United States, Canada, Syria, Manchuria, Korea, Formosa, Philippine Islands, Borneo, Celebes, New Guinea, New Caledonia and New Zealand, 31 species, 18 Ethiopian, type *Dineutus politus* MacLeay Dineutus (*s str* )

$A^2$ Body shape representing several types of modification from the broad oval form of the primitive type, narrower, usually under 12 mm in length (except three species)

- $B^1$. Body narrower, length under 12 mm (except *C longimanus* Oliv 11 5–16 mm ), elytral apex evenly rounded or sinuate (bispinose in *C longimanus* Oliv ), North America, 13 species, type *Cyclinus assimilis* Kby , 1837, = *C. americanus* Say Cyclinus Kby
- $B^2$ Body narrower, exterior elytral angle distinct and usually produced as a spine, at least in males
  - $C^1$. Mid-apical margin of elytra not produced as a spine, thorax and elytra not margined with testaceous, occurs throughout the range of the genus in the Old World except Canary Islands, Arabia, northern China, Manchuria, Korea, Japan, Riu-Kiu Islands, Formosa, 12 species Cyclous Esch
  - $C^2$ Mid-apical margin of elytra produced to form a spine, thorax and elytra margined with testaceous, length 7–9 mm , eastern and northeastern portion of range of genus Australia, New Guinea, Celebes, Java, Borneo, Sumatra, Malay Peninsula, Burma, Siam, Ceylon and eastern India, China, Formosa, Riu-Kiu Islands, Japan, Korea, Manchuria, 3 species, type *Gyrinus spinosus* F. Spinosodineutes, n subg

If the reasons that have been adduced for considering Enhydrus primitive and Dineutus as derivative from it are sound, there is good ground to believe that the subgenus Dineutus represents the generalized type from which the other subgenera have been derived, Cyclinus in North America and Cyclous and Spinosodineutes in Malaysia. Its distinguishing characters are its large size, broad oval form, and lack of specialization of the elytral apex The apex is strongly dentate in *D sinuosipennis* Cast. of Madagascar, but the spines are not homologous with those in Cyclous and Spinosodineutes, but apical and the result of an exaggerated sinuosity The mesal spine is a production of the sutural angle, which is not the case in Spinosodineutes The only species known to be less than twelve millimeters in length are two Arabian species, whose aberrance is not surprising in view of their occurrence at the extreme periphery of the range of the group. The species are distributed from Australasia to Ethiopia and Central America Ethiopian, 18 species; Australasian, 5 species, Indo-Malaysian, 4 species, North American, 4 species. This indicates Ethiopia as the center of dispersal of the group

The species that have been assigned to Cyclinus do not represent a very decided departure from Dineutus (*s str.*). They are distinguished from the latter by their narrower, less oval form and smaller size, which, except in D *longimanus* Ol, never exceeds a length of twelve millimeters The Mexican *D solitarius* Aubé presents scarcely any deviation in form from Dineutus (*s str* ) From this condition there are numerous gradations to such extremely differentiated species as *D. discolor* Aubé, *D angustus* Lec and *D. longimanus* Ol The twelve species of this subgenus range from Nicaragua and the West Indies to Canada. Their absence from the Pacific Coast should preclude the possibility of Asiatic affinities

The twelve species that are grouped under the subgeneric designation Cyclous are distinguished from Dineutus (*s str* ) by their narrower bodies, smaller size and distinct external elytral angle. The last two characters show a distinct gradation, which is a material aid in indicating the probable center and origin and path of dispersal of the group.

The presence in New Guinea and Celebes of those species that most closely approximate Dineutus (*s. str* ) as regards size and the feeble development of the elytral apex indicates this general region as the place of origin of the group. It is further significant that Dineutus (*s. str* ) does not occur on either of these islands The species are *D tetracanthus* Rég 10–16 mm, *D pectoralis* Rég 12–16 mm, *D mesosternalis* Rég. 12.75–13 5 mm.; *D. ritsemai* Rég 11 mm Régimbart's figures of *D pectoralis* and *D. ritsemai* illustrate species with the elytral apex scarcely more than obtuse *D. inflatus* Blackb., Australia, *D. janthinus* Blanch. 9 mm, Fiji Islands, and *D australis* Fab. 8.5–9 mm., New Zealand, New Caledonia, Australia, Malay

Archipelago and the Philippine Islands represent the spreading of this group into adjacent regions. The males of the last species have the external elytral angles distinctly spinose The females apparently have a tendency to retain the ancestral condition and have the elytral apices truncate only with the external elytral angles distinct but not spinose An opposite tendency is manifested by the species of Cyclinus in which the derivative characters are more strongly developed in the female

The five remaining species of this subgenus have a serrate and well-developed spinose elytral apex and represent the more western extension and more derivative development of the group *D. sharpi* Rég 11–12 mm, Guinea, *D subspinosus* Klug 8 5–9 mm, Ethiopia, Syria, East Indies (?); *D. unidentatus* Aubé 7.5–8 mm, Ceylonese region, Burma, Java, China, *D. curtulus* Rég 6–7 5 mm, Philippine Islands; and *D fauveli* Rég 7 5–8 mm, Guinea Coast. These species represent the further development of the primitive Cyclinus tendencies in an adjacent region.

The subgeneric name Spinosodineutes is applied to a group of three closely related and widely ranging species *D. marginatus* Sharp, East Indies and India to Japan and Manchuria; *D neoguineensis* Rég., New Guinea and Australia, and *D. spinosus* F., East Indies, Siam, Burma. In Japan and Manchuria it is the only Dineutus that occurs It is characterized by having the spine and the external angle of the elytral margin well developed, a second spine developed from the apical margin of the elytra, and the thorax and elytra with a testaceous margin Of the three species, *D marginatus* has a relatively feebly developed apical spine and may be considered primitive. *D neoguineensis* with an intermediately developed apical spine and *D spinosus* with a strongly developed apical spine may be considered derivative. The entire group is a derivation from the more specialized members of Cyclinus, and may represent the re-occupation of the eastern area by a derivative of the more western branch of that subgenus.

Porrhorrhynchus is in general a genus of five very large species inhabiting Ceylon, Malay Peninsula, Indo-China, southern

China, Japan (?), Sumatra, Java, Borneo, Celebes and New Guinea They are characterized in the literature chiefly by the triangular labrum, but also by modifications of the male tarsus *P. landaisi* Rég is the only species which I have been able to dissect In it the eight-segmented flagellum, the bilobed caudal margin of the mesoscutellum, and the undivided mesoscutum were found to be further characters of possible diagnostic significance The five species are apparently not closely interrelated, but represent widely divergent tendencies, so that it is best not to generalize Were it not for the eight-segmented flagellum, *P landaisi* could be regarded as a derivative Dineutus Its ensemble of characters is more derivative than Dineutus, and it is certainly generically distinct from it The species of Porrhorrhynchus are said to inhabit the pools of mountain streams and to be powerful and active swimmers The distinctly narrowed anterior end of *P landaisi* and *P. marginatus* Cast. may probably be looked upon as an adaptation to running water It is closely paralleled by the form of *Dineutus discolor* Aubé

Nothwithstanding the more primitive antennae, an ensemble of characters shows that Androgyrus and Macrogyrus are more derivative than Enhydrus The narrower form, the absence of the wedge-cell and the tip of Cu in the wing, the incomplete tresternasuture, and the feeble elytral striae are all indicative of a more derivative structure than is present in Enhydrus. Macrogyrus can be regarded as a direct derivative of Androgyrus, its prominent external angles, eight-segmented flagellum, and uniformly narrow form all being derived from the condition in Androgyrus

The six species of Androgyrus are confined to the western margin of South America from Venezuela to Chile and Patagonia. Such a range does not represent a very extensive overlapping of the range of Enhydrus and it is entirely possible that Androgyrus arose in more or less isolation in western South America as a result of a modification of an enhydroid ancestor with a nine-segmented flagellum. Considerable progressive change in form is indicated among the species of Androgyrus from the relatively broad *A buqueti* Aubé of Columbia to the narrow *A. serratopunctatus* Rég of the more southern portions of the continent

A Pacific or Antarctic land connection is necessary to account for the migration of Macrogyrus to Australia The species of Macrogyrus occur in Australia, New Guinea, Timor, Timor-Laut, Sumbawa and New Caledonia, but not in Tasmania, New Zealand, or Celebes The following Table of the groups of species of Macrogyrus, slightly modified from Régimbart, will indicate the major tendencies manifested by the species

TABLE OF GROUPS OF SPECIES OF MACROGYRUS RÉG

A¹ Metasternal wings in the form of broad triangles and not strongly narrowed between the coxae
  B¹ Apex of elytra truncate with very blunt angles, 2 species
  B² Apex of elytra sharply truncate with sharp angles, 17 species
A² Metasternal wings in the form of elongate triangles, narrowed between the coxae
  C¹ Prothorax and elytra not bordered with yellow, 4 species
  C² Prothorax and elytra bordered with yellow, 1 species (*M paradoxus* Rég.)

### 4. *Orectochilini*

The Orectochilini represent an adaptation to running water, and correlated with this are some of the most important definitive characters of the tribe an increased antero-posterior compression, a lengthening of the caudal abdominal segments and genitalia, and a row of hairs on the meson of the last two abdominal sterna In addition, all the species possess an area of pubescence along the margin of the dorsum, which in many species is expanded to cover large areas or all of the dorsal surface, and may, perhaps, serve as a water-repellent and an aid in maintaining the water line of the animal The genera may be distinguished by the following Table.

TABLE OF GENERA OF ORECTOCHILINI

A¹. Scutellum visible, though minute, Old World
  B¹ Dorsal eye not anterior to ventral eye, mesocoxae separate and narrowed externally; 96 species, Oriental and Palearctic, one species Ethiopian . .. .... . .. Orectochilus.

B². Dorsal eye anterior to ventral eye, mesocoxae usually in contact and rounded externally, 70 species, Ethiopian Orectogyrus

A² Scutellum concealed, dorsal eye anterior to ventral eye, head strongly brachycephalic, mesocoxae separate, 45 species, America Gyretes

The evolutionary process involved is much the same as in the Enhydrini. In different parts of the world more or less divergent lines have developed The evolutionary tendencies of the tribe may be summarized as follows (1) a tendency towards lateral compression involving (a) a drawing together of the mesocoxae, (b) an increased convexity and narrowing of the body form, and (c) a narrowing of that portion of the metacoxa mesad of the coxacarina, (2) a brachycephalic tendency involving in Orectogyrus only a slight displacement cephalad of the dorsal eye, but in Gyretes a general antero-posterior compression of the head, (3) a tendency in Orectochilus towards a lengthening of the labrum, (4) a tendency for the marginal area of dorsal pubescence to spread over the rest of the dorsum, (5) a tendency for the elytral apex to depart from the simply truncate form either, as in Orectochilus (*s str*), by becoming oblique, or, as in all the other groups, by becoming spinose laterad, (6) a tendency for the dorsum to develop a yellow margin; and (7) perhaps some tendency towards a reduction in body size The primitive orectochilin was a gyrinid embodying each of these features to a minimum degree, a condition that is fulfilled to a remarkable extent by certain Bornean species (*Orectochilus crassipes* Rég and *O dispar* Rég.).

The genus Orectochilus is distributed from Celebes and Timor to Philippine Islands, Formosa, Japan, Riu-Kiu Islands and southern Finland, Scotland, Spain and north Africa, with a single species from the Belgian Congo. The two subgenera and lesser groups are indicated in the following Table, which is modified from Régimbart, the numbers in parentheses indicate the numbers of Régimbart's groups.

### TABLE OF SUBGENERA AND GROUPS OF ORECTOCHILUS

A¹. Thoracic and elytral pubescence confined to margin; Oriental region with two closely related species in China, two in Japan, and one in Congo; 85 species, type *O. javanus* Aubé subgenus Patrus Aubé.

- $B^1$. Labrum more than twice as wide as long, not or little rounded cephalad, 59 species
  - $C^1$ Pronotum and elytra not bordered, rarely with elytra alone very indistinctly bordered with yellow, 36 species Group I (I)
  - $C^2$ Pronotum and elytra distinctly bordered with yellow, 40 species Group II (II)
- $B^2$. Labrum at most twice as wide as long, 36 species
  - $D^1$ External angle of elytral truncature sometimes slightly pointed, but never a spine, pronotum and elytra bordered with yellow, 12 species Group III (III)
  - $D^2$ External angle of elytral truncature acute and more or less prolonged into a spine, 12 species.
    - $E^1$ Elytra not bordered with yellow, 1 species ,Group IV (V)
    - $E^2$ Elytra bordered with yellow, 11 species Group V (VI)

$A^2$ Thorax and elytra entirely pubescent, truncature of elytra more oblique in female than in male, prolonging the elytra caudad, pseudofrontal ridge absent, area of metacoxa mesad of coxacarina extremely narrow, Palearctic with two species in India and two in Burma, 13 species, type *O villosus* O Müller subgenus Orectochilus (*s. str* ) (IV)

The subgenus Patrus represents the primitive type of Orectochilus. With the exception of two closely related species of Group II that get into China (*P chinensis* Rég and *P sevesini* Rég ), two species (*P nipponensis* Zait , Group II, and *P. corniger* Zait , Group III) from Japan, and a single species of Group III from Stanleyville, Belgian Congo (*P. africanus* Ochs, 1923, pp. 169–171), all the species of this subgenus are confined to the Oriental region from India and Ceylon to the Philippine Islands, Celebes, Timor, and Flores, indicating this region as the place of origin of the genus.

Certain species of Group I possess a combination of characters that is quite significant. They are of large size (9–12.5 mm long), form not especially narrowed or convex, procoxacavae distant from anterior margin of prosternum;—it is close to it in all other Orectochilini — coxacarina moderately distant from the mesal margin of the metacoxa, mesocoxae widely separated, labrum short, dorsum not margined with yellow, elytral truncature decidedly rounded in the females (*O. corpulentus* Rég , etc ). All these are features that can be looked upon as strongly reminiscent of an enhydroid ancestry. The correlation of the large size with other primitive characters gives strong reason for believing that this was the primitive condition of the genus and an additional reason for relating this tribe with the Enhydrini Even within Group I certain of the species are small and of narrow convex form In Group II the area of the metacoxa mesad of the coxacarina has become narrowed, the precoxacavae have approached close to the anterior margin of the prosternum, the dorsum has developed a yellow margin, and the mesal margins of the mesocoxae are nearly in contact Groups III to V involve species in which the labrum has become at least half as long as wide

Orectochilus (*s str*) includes a group of highly derivative species, the characters of which have been mentioned in the table The area of the metacoxa mesad of the coxacarina is narrower than in any other Orectochilini It is the only orectochilin group to lose all trace of the pseudofrontal ridge The thirteen species of the subgenus are closely related. Four of them are oriental two from Burma, one from Madras and one from Sikkim. The remaining nine are Palearctic, occupying an area that is greater in extent than that of all the rest of the genus put together, and extending from China and Japan to Spain and England Seven of the nine occur in the eastern part of the area, three in Japan and four in China One species (*O involvens* Fald ) occurs in central Asia and one species (*O villosus* O. Müll ) in Siberia, Europe and the Mediterranean region. The center of dispersal is probably somewhere between Burma and China It represents the extreme development of the orectochilin stem in one direction

The seventy odd species of Orectogyrus are confined to the Ethiopian region. The pronotum and thorax are always bordered with yellow which may be taken as evidence that the genus was derived from some yellow-margined Orectochilus Its chief advances in specialization over Orectochilus consist in the drawing together of the mesocoxae (except in *O mirabilis* Rég and *O lanceolatus* Rég of southeastern Africa), the cephalad migration of the dorsal eye, the six-segmented flagellum, and the strong development of the pseudofrontal ridge The following is an attempt to modify Régimbart's table of groups in accordance with their increasing derivativeness The numbers in parentheses are the numbers of Régimbart's groups.

### TABLE OF GROUPS OF SPECIES OF ORECTOGYRUS RÉG.

$A^1$ External angles of elytral truncature variable, obtuse, square, or slightly acute, but never spinose, 65 species
  $B^1$ Pronotum always with smooth area, and elytra always in female and nearly always in male with a variable smooth area
    $C^1$ Smooth area of elytra at least sutural, but quite variable
      $D^1$ Mesocoxae separated, *O mirabilis* Rég, *O lanceolatus* Rég. Group I (IV, in part)
      $D^2$ Mesocoxae approximate, 27 species. Group II (IV, in part)
    $C^2$ Smooth area of elytra more or less developed along suture, but also with extensions, 35 species Group III (V)
  $B^2$ Pronotum and elytra entirely pubescent, 1 species, Madagascar Group IV (III)
$A^2$ External angles of elytral truncature acute and more or less produced, 5 species
  $E^1$ Elytra with smooth sutural space, 2 species Group V (II)
  $E^2$ Elytra entirely pubescent, 3 species Group VI (I)

The tendency, as in Orectochilus, is away from the simply truncate elytral apex and towards a spreading of the dorsal pubescence culminating in complicated patterns, involving raised areas of the elytral disc, or a wholly pubescent dorsum. The failure of the larger size of several of the species to be correlated with primitive characters seems to indicate a secondary increase in size. Orectogyrus represents the culmination of the orectochilin stem in the Ethiopian region.

The forty-five species of Gyretes represent the development of the Orectochilini in America, ranging from Patagonia to Mexico and the West Indies. Two species are found north of Mexico *G. californicus* Rég from California and *G. sinuatus* Lec. from California, Texas, and Quincy, Illinois. Their nine-segmented flagellum, weak pseudofrontal ridge, and failure of the mesal margins of the mesocoxae to meet are evidence that Gyretes is derived from an orectochiloid rather than an orectogyroid stock. The strongly developed brachycephalization, invisible scutellum, and strongly convex body indicate considerable advance in derivativeness of Gyretes over Orectochilus. Its ensemble of characters points it out as the most derivative of all gyrinid genera.

The species are closely allied and present a difficult taxonomic problem. Régimbart distinguished two groups (1) those with the external angle of the elytral truncature a right angle or obtuse (34 species), and (2) those with the external angle of the elytral truncature acute or spinose (11 species) In each of the divisions are species possessing an extremely narrow testaceous margin to thorax and elytra There is a tendency in some of the species for the primitively sharply defined marginal areas of pubescence on the margins of the thorax and elytra to spread, but the whole dorsal surface is never covered.

### 5. *Gyrinini*

The absence of the galea, the smaller size, the eleven-striated elytra, and the truncate elytral apex involving the complete absence of any external angle are the chief characters that demand that the Gyrinini be considered divergent from the Enhydrini. Among their simple derivative features are the absence of the corpotentorium, the loss of the wedge-cell in the wing, the encroachment of the metacoxae upon the metasternum In addition to these, they have the following peculiar derivative characters that make their association with the Orectochilini impossible the seven-segmented flagellum, the somewhat narrowed scutellum, the peculiar structure of the metanotum, the loss of the tip of Cu in the wing, and the foreshortening of the head that is different from that in Gyretes, involving the close approach of the antacaval ridge to the exoculata and, in Gyrinus, the cephalad migration of the dorsal eye.

The two principle genera of the tribe may be recognized by the following Table.

#### TABLE OF THE GENERA OF GYRININI

$A^1$. Elytral striae present as deeply sculptured furrows, dorsal eye scarcely anterior to ventral eye, epinotum smooth Aulonogyrus.
$A^2$ Elytral striae present as rows of punctures, dorsal eye anterior to ventral eye, epinotum with transverse groove .. Gyrinus.

Ochs (1924, p. 231) describes a genus, Paragyrinus, founded on *Aulonogyrus arrowi* Rég (northwest India), *A. vitalisi* Peschet (Indo-China) and *Paragyrinus sinensis* Ochs (Canton) It apparently represents a yellow-margined aulonogyroid stock in the Oriental region in which the process of attenuation (narrowed mesoscutulis) and brachycephalisation (cephalic movement of the dorsal eye) are present.

AULONOGYRUS divergent feature elytral striae present as furrows, primitive features dorsal eye scarcely anterior to ventral eye, epinotum smooth, tresternasuture entire, derivative features propygidium strongly trilobed, arms of metafurca fused distad, suture separating qua- and quitarsomeres in meso- and metapods obsolete, tendency to develop species with yellow marginal area on thorax and elytra

GYRINUS divergent feature elytral striae present as rows of punctures, primitive features propygidium not or slightly trilobed, suture separating qua- and quitarsomeres in meso- and metapods present, species without yellow margin to thorax and elytra; derivative features dorsal eye anterior to ventral eye as a result of a strong foreshortening of the head, epinotum with a transverse median impression, tresternasuture incomplete mesad.

It appears from this tabulation that Aulonogyrus and Gyrinus represent divergent tendencies of which Aulonogyrus stands much nearer to the primitive gyrinin than does Gyrinus.

There are two subgeneric groups in Aulonogyrus, a primitive group of eight entirely black species and a derivative group of twenty species that have the thorax and elytra margined with yellow. Seven of the eight black species are Ethiopian. One (*A. goudoti* Rég.) of the seven is from Madagascar. The eighth species (*A. obliquus* Walk.) is from Ceylon, but this is in accord with the close affinities that the Ethiopian and Oriental faunas are known to have. This indicates Ethiopia as the center of dispersal of these, presumably the more primitive species of Aulonogyrus. Of the twenty yellow-margined species, sixteen are Ethiopian. Single species only inhabit Australia (*A. strigosus* F.), New Caledonia (*A. antipodes* Fauv.) and central Europe as far as Transcaucasus (*A. concinnus* Klug.). Two species (*A. concinnus* Klug. and *A. striatus* F.) inhabit the Mediterranean region. The Ethiopian region is thus very clearly indicated as the center of dispersal of this group likewise, with a slightly more pronounced dispersal of species into outlying regions.

Three subgenera of Gyrinus may be indicated

GYRINUS (*s str* ) scutellum unmodified, rows of punctures on both disc and margins of elytra, cosmopolitan except in central Africa, Tasmania, and the Pacific islands beyond New Guinea, New Caledonia, and New Zealand, 84 species

GYRINULUS Zaitzev (type *G minutus* L.) scutellum with a minute longitudinal carina, rows of punctures on both disc and margins of elytra, size small (3 4-4 5 mm ), Holarctic, 2 species

NEOGYRINUS, n subgen (type *G. chalybaeus* Perty) scutellum unmodified, elytra with rows of punctures at sides only, British Guiana, Brazil, northern Argentina, Peru, Bolivia, 5 species

The modification of the scutellum and loss of the discal rows of striae indicate that Gyrinulus and Neogyrinus are derivatives of Gyrinus (*s str* )

The species of Gyrinus (*s str* ) have a distribution as follows South America, 10, Central America, Mexico, West Indies, 6, Nearctic, 31, Palearctic, 31 (24 species, 7 varieties), Reunion and Mauritus, 1, Madagascar, 4, South Africa (Cape of Good Hope, Natal, Angola), 4, Ceylonese region, 2, Burma, 1, Malaysia, 4, Australia, 2, New Caledonia, 2, New Zealand 1, or, tabulated by regions, Neotropical, 16, Holarctic, 61, Ethiopian, 8, Oriental, 6, Australasian, 5

In the light of such a situation and until the interrelationships of the species can be worked out, the Holarctic region is indicated as the center of dispersal of the subgenus *Gyrinus opacus* Sahlb seems to be truly circumpolar It is recorded from Great Britain, Scandanavia, Finland, northern Russia, northern Siberia, Alaska, Alberta, Manitoba, Ontario, Labrador, Greenland, Iceland.

It is now possible to suggest on geographical grounds what there was reason to suspect on the basis of structure, namely, that Aulonogyrus and Gyrinus represent divergent tendencies of some homogeneous proto-gyrinin stock, probably in Ethiopia and Holarctica respectively. The Holarctic line became the more highly specialized of the two It is the only gyrinid stock that became adapted to a subarctic climate. Its brachycephalization gives further evidence of a high degree of specialization.

Because of this and its strategic geographical position, it has access to all parts of the world. In central Africa it encountered the closely allied Aulonogyrus, and it must be supposed that this genus, though less derivative than Gyrinus, had taken such complete possession of its African domain that species of Gyrinus were able to do no more than establish themselves on the periphery of its range

In the Holarctic region the subgenus Gyrinus (*s str.*) has given rise to the subgenus Gyrinulus, represented by *G minutus* L (central and northern Europe, Siberia, northern Nearctic region, but not recorded from Labrador, Greenland, or Iceland), which, in the extreme eastern portion of its range (the Atlantic Coast of North America from Massachusetts to Florida) differentiated to form the closely allied *G rockinghamensis* Lec In the Neotropical region the subgenus Gyrinus (*s str*) has given rise to the subgenus Neogyrinus (5 species), characterized by the absence of rows of punctures from the disc of the elytra

## 6 *Zoögeographical Criteria*

The Gyrinidae consist of three tribes, each separated from the others by a definite set of characters The intratribal variation is slight and the groups of species within the tribes grade gradually from the least to the most derivative. So gradual is this process and so little extinction has apparently occurred within the tribes that the attempt has been made in the preceding pages to indicate centers and lines of dispersal. The assumptions that have been made are formulated below[1] In this connection the fact should not be overlooked that there are those who discredit any attempt to interpret zoögeographical data on the ground that so much extinction has undoubtedly occurred that the present distribution is without significance

1 The center of origin is located within or very near the periphery of the range of the group under consideration.

2 The location of the center of origin is indicated by the distribution of the most primitive types within the group.

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[1] The author is indebted to Adams' ten criteria (1902, pp 115–131) and to Professor A G Ruthven's lectures on zoögeography (1921)

3. The location of the center of origin tends to be indicated by the area occupied by the largest number of species of the group Areas occupied by smaller numbers of species, especially when the number is as low as one or two, can be looked upon as having been populated by migration from the center.

4 The center of origin is located within or very near the periphery of the range of the group from which the group under consideration has been derived

The degree of probability increases as more than one of these last three criteria indicate the same region

In general in a group in which little extinction has occurred, the primitive types remain at the center of dispersal It is otherwise in the case of groups in which much extinction has taken place and whose distribution is discontinuous. In such a case, the primitive types are likely to occur on the periphery of the range of the group and to represent the survival of types once derivative relative to the common ancestor of the entire group Subsequent to the arrival of the now primitive type on the periphery of the range, further evolution occurred in the center of the range, the ancestral type was there exterminated, and there developed in its place a type more derivative than the type at the periphery

## 7 *Zoögeographical Regions*

The Neotropical region is characterized by four endemic groups· Enhydrus, Androgyrus, Gyretes and Neogyrinus. Of these, three are South American. The occurrence of two species of Gyretes north of Mexico does little to detract from the Neotropical character of the genus.

The Nearctic region is characterized by a single subgenus, Cyclinus, most of whose species occur there

The Ethiopian region is isolated by the Sahara Desert almost as completely from the Palearctic region as by an ocean. Only three species, one Dineutus and two Aulonogyrus, have been able to pass this barrier, apparently by way of the Nile Valley, and of these Dineutus does not occur in the region north of the Sahara Desert itself, so that four genera fail to cross the

Sahara Desert (Gyrinus and Orectochilus [*s str* ] on the Palearctic side and Dineutus and Orectogyrus on the Ethiopian side) as compared with the one, Aulonogyrus, that does The affinities of the Ethiopian region with the Oriental and Australasian regions are many times greater than with the trans-Saharan area Its affinities with the Neotropical region are likewise marked The Ethiopian region is the center of dispersal for Dineutus (*s str* ), Aulonogyrus and Orectochilus, the last one of which is endemic

The Oriental region is the center of dispersal of Cyclinus, Spinosodineutes, Porrhorrhynchus and Patrus It is one of the least sharply defined of the regions All the Oriental groups are represented by straggling species in the Mongolian area. If a line is to be drawn between the Oriental and Australasian regions, it must be between Celebes and New Guinea with the islands of Sumbawa and Timor a transitional area. Patrus stops to the west of the line and Macrogyrus to the east Five groups (Dineutus [*s str* ], Cyclinus, Spinosodineutes, Porrhorrhynchus, Gyrinus) cross this line as compared with three (Macrogyrus, Patrus, Aulonogyrus) that do not. Macrogyrus, a derivative of the South American Androgyrus, is the only endemic Australasian group. The distribution of Aulonogyrus is peculiar Single species of the yellow-margined group occur in Australia and New Caledonia None occur in the East Indies. The single Ceylonese species belongs to the unicolored section of the genus

With the exception of the Ethiopian Orectogyrus, the Palearctic region contains straggling representatives of all the Ethiopian and Oriental groups Only Orectochilus (*s str.*), a derivative of the Oriental Patrus, appears to have become especially adapted to Palearctic conditions. Four species of Patrus are Indo-Burmese, nine are Palearctic.

The question of zoögeographical regions is largely a matter of barriers acting in such a way as to render the fauna of one area markedly different from the fauna of another. The alate condition of the Gyrinidae enables them to transcend the limits of a particular drainage system and to distribute themselves as does any other winged terrestrial animal The barriers that have been efficient in limiting and determining their distribution are, in order of their importance (1) oceans, (2) deserts, (3) climate, (4) biological factors Of these the first two are correlated with the distribution of the fresh-water habitat of the animal, i e the evident lack of such habitats in marine and desert areas The extreme efficiency of the Sahara and Arizona deserts have been noted Climatic factors are probably largely responsible for limiting distribution to the north, and biological factors are involved in the apparent inability of certain types to invade the territory of a closely related group

### 8 *Land-Bridges and Geological History*

The relation of Androgyrus (South America) and Macrogyrus (Australia) is such that a direct migration route from western South America to Australia must be postulated

An Atlantic land-bridge is required (1) for the derivation of the Ethiopian Dineutus from the South American Enhydrus, (2) for the remigration of Dineutus to America, (3) for the derivation of the American Gyretes from Orectochilus

The Indo-Madagasco-African land-bridge, Lemuria, is indicated by the close affinities between the fauna of Africa and the orient The distribution of Dineutus, the presence of a single species of Aulonogyrus in the Ceylonese region, the presence of Gyrinus in India, Madagascar and South Africa, but not in central Africa, are all indications of this The derivation of Orectogyrus from Orectochilus may be accounted for either in terms of Lemuria (this accounts for their presence in Madagascar), or as the result of a general faunal movement from the east by way of Arabia that some naturalists postulate at a relatively recent date.

An Asio-Australian land-bridge is required to account for the continuous distribution of Dineutus (*s str*), Cyclinus, Spinosodineutes, Porrhorrhynchus and Gyrinus from Asia to Australia or New Guinea. The stretches of open water from Asia to Australia are none of them great, under fifty or one hundred miles, and may present slight difficulty to small winged animals easily blown by the wind This will not explain the failure of

Patrus and Macrogyrus to surmount them, unless there are biological barriers at work

The alternatives that the zoölogist faces are clear cut In the ordinary course of nature terrestrial animals are not able to pass over wide expanses of water Either they must have made use of land connections, or their present distribution must be accounted for entirely on the basis of fortuitous means of dispersal, as drifting trees or dispersal by wind Geological time is long and the chance of populating a new country with the progeny of a single pair or a single gravid female is not impossible Such a means of dispersal, if effective, would account for the present geographical relationships nearly as well as a system of land-bridges, for chance would always favor fortuitous dispersal between geographically adjacent rather than geographically non-adjacent areas Certain investigators insist that such an explanation is to be preferred to the postulation of land-bridges for which there is no structural evidence

However, an increasing number of zoologists and paleontologists are coming to accept land-bridges, and a certain amount of agreement has been reached concerning some of the more general features Therefore, the distribution of the Gyrinidae has been correlated with some of the more widely accepted paleogeographical formulations Metcalf's (1923, pp 296–308) paleogeographic charts, chiefly modified from Arldt, have been made the basis of this study

North Atlantic and Bering Strait land-bridges are shown on Metcalf's charts to have had an intermittent existence throughout practically all of post-Permian time A trans-Pacific land-bridge from Ecuador to Australia excluding New Zealand and Tasmania is shown (*ibid*, p 303) for late Cretaceous time and a communication by way of Antarctica including New Zealand and Tasmania in Oligocene time (*ibid*, p 304) Either of these land-bridges would account for the presence of Macrogyrus in Australia, though their absence from New Zealand and Tasmania favors the first Metcalf (*ibid*, p. 303) places "the final separation of Africa from tropical America in the middle Cretaceous . . . though Arldt shows late Cretaceous and early Tertiary connection" He shows Lemuria for the last time in the early Cretaceous (*ibid.*, p 300), though Arldt continues it into late Cretaceous. The last Asio-Australian land-bridge is shown for late Jurassic time, at which period both the Atlantic and Lemuria land-bridges were open A connection extending as far as Celebes and Java, but not beyond, is shown for Pliocene time

It is possible to suggest the geological history of the Gyrinidae, though such a reconstruction has only such validity as have the land-bridge hypotheses themselves

Previous to late Jurassic time Enhydrus developed in South America and its derivatives, Dineutus, Cyclinus, Spinosodineutes and Porrhorrhynchus migrated to Africa, India and Australia. Previous to the same period Gyrinus had developed in the Holarctic area and Aulonogyrus had developed in Africa and both had migrated to Australia.

Before middle Cretaceous time Gyrinus had occupied South Africa, the unicolorous Aulonogyrus had migrated to the Ceylonese region, and Dineutus had migrated back to America, where it subsequently gave rise to Cyclinus.

Subsequent to the closure of the Australian land-bridge in late Jurassic time, but before the breaking down of the Atlantic land-bridge and possibly Lemuria, the Orectochilini developed in southeastern Asia, possibly from enhydrin stock, and migrated to America and Africa The Ethiopian orectochilins differentiated to form Orectogyrus subsequent to the migration of Gyretes to America, since Gyretes exhibits only general orectochilin and no special orectogyroid characters.

Previous to late Cretaceous or Oligocene time Androgyrus developed in South America and in one of these two periods, probably the earlier, its derivative, Macrogyrus, migrated to Australia and New Guinea

In Pliocene time Patrus was able to attain Celebes. Its presence in Flores and Timor may have to be ascribed to fortuitous dispersal.

In this manner all the major facts of present-day gyrinid distribution are accounted for without doing violence to any morphological, paleontological, or geographical detail, except that to account for the Australasian species of yellow-margined Aulonogyrus, it must be assumed that they passed through the Oriental regions on the way and have subsequently become extinct. The recent discovery of Paragyrinus in this region lessens this difficulty, perhaps

Extremely striking is the conclusion that the essential features of gyrinid structure and distribution were established in Mesozoic time Even some of the genera, subgenera and species (*Dineutus australis* F. and *Gyrinus convexiusculus* MacLeay are said to be found on both sides of the Celebes–New Guinea line) may have come into existence at this time Recent species of Gyrinus have been reported from the interglacial period It is said to be the case with ants (Wheeler, 1923, p 7) and seems to be true of beetles that types are able to continue in practically unmodified form over very long periods of time. The race of mammals has arisen and entered into a decline. The gyrinids are almost as they were in the age of dinosaurs.

## III. SUMMARY

The conclusions suggested in the preceding pages may be summarized as follows·

1. The Gyrinidae arose from some dytiscoid stock in Triassic or early Jurassic time.

2. The Gyrinidae exhibit the general adaptations and phylogenetic tendencies of the Dytiscidae, but show an increased response to aquatic and especially to surface conditions

3. The phylogenetic tendencies within the Gyrinidae have been in the direction of (1) decrease in size, (2) a loss of the galea and corpotentorium, (3) a modification of the elytral apex, (4) an antero-posterior compression, and (5) a narrowing of the body.

4. Three tribes of Gyrinidae are distinguished Enhydrini, Orectochilini and Gyrinini, and of these the first two form the subfamily Enhydrinae and the last the subfamily Gyrininae.

5. The Enhydrini and Gyrinini represent two early lines of divergence. The most primitive enhydrins are South American;

the most primitive gyrinins are Ethiopian. If the land-bridge hypothesis be accepted, previous to late Jurassic time these two tribes had attained a cosmopolitan distribution Macrogyrus represents a second Australian invasion by the Enhydrini from South America in Cretaceous or Oligocene time

6 The Orectochilini are a highly derivative, strongly narrowed gyrinid stock closely related to the Enhydrini They represent a general adaptation for life on the surface of running water On the basis of the land-bridge hypothesis it may be supposed that, subsequent to the closure of the Australian land-bridge in late Jurassic time, but previous to the breaking down of the other land-bridges in Cretaceous time, this tribe developed in southeastern Asia and migrated to Africa and South America. In Pliocene time they were able to attain Celebes, but are absent from New Guinea and Australia.

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# THE METAMORPHOSIS OF THE CALIFORNIAN RIBBON FISH, *TRACHYPTERUS REX-SALMONORUM*

CARL L. HUBBS

## TRACHYPTERUS REX-SALMONORUM Jordan & Gilbert

*Trachypterus altivelis* Jordan and Gilbert, *Proc U S Nat Mus*, 3, 1880 (1881), p 455, 4, 1881, p 52, Bean, *ibidem*, p 265, Jordan and Gilbert, *Bull U. S Nat Mus*, 16, 1883, p 618 (apparently not of Kner)

*Trachypterus rex-salmonorum* Jordan and Gilbert, *Proc Calif Acad Sci*, (2) 4, 1894, p 145, Pl 9, Jordan and Evermann, *Bull U S Nat Mus*, 47, Pt 3, 1898, p 2599, Jordan, *Guide to the Study of Fishes*, 2, 1905, p 478, Fig 426, Starks, *Ann Carn Mus*, 7, 1911, p. 212, Sette, *Copeia*, No. 122, 1923, p 93

*Regalecus russelli* Jordan, *Guide to the Study of Fishes*, 2, 1905, p 473 (in part), Jordan and Starks, *Proc U S. Nat. Mus*, 32, 1907, p 72 (not of Shaw).

*Trachypterus seleniris* Snyder, *Proc. Acad Nat Sci. Phila*, 1908, p 319

*Trachypterus sp* Holder, *Fishes of the Pacific Coast*, 1912, p 70, Fig 27; Thompson, *Calif Fish and Game*, 5, 1919, p. 95

AN examination of ten specimens of Trachypterus from California indicates that *T. seleniris* is merely the adult of *Trachypterus rex-salmonorum* These specimens vary in length from 10 to 1520 mm., and illustrate very well the remarkable changes which this species undergoes with age

The measurements of the ten specimens used in this study are listed in Table I. *Specimen 1*, only 10 mm. long (when the body flexure is straightened out), is a larva still retaining a large yolk sac; it was collected December 20, 1905, having been washed ashore at La Jolla, California, during a northwest wind; it was turned over to the writer by the Scripps Institution for

Biological Research *Specimen 2*, 25 mm in axial length, was taken by the California State Fisheries Laboratory in a trawl hauled at an intermediate depth of forty fathoms over deep water, 8 miles S S W of the west end of Santa Catalina Island, California. *Specimen 3*, 102 mm long, is the one from near Monterey reported on by Sette (1923), the proportionate measurements for this specimen are computed from the absolute values given by Sette, in the table on p 94 of his paper *Specimens 4 and 5* are young fishes 130 and 145 mm long taken at Avalon, Santa Catalina Island, these and the adults (Nos. 8 and 9) from the same locality, apparently served as the basis for the records of Regalicus from Catalina Island *Specimen 6* probably came from Pacific Grove, California *Specimen 7*, 285 mm long, is the type of *Trachypterus rex-salmonorum*, collected off San Francisco, the proportionate measurements, like those for *Specimen 3*, are computed from the values given by Sette (1923). *Specimens 8 and 9* are adults, 860 and 1000 mm long, from Avalon *Specimen 10* is the large type, 1520 mm. long, of *Trachypterus seleniris* Snyder (1908), from Monterey.

It seems clear that all these specimens represent a single species As shown by the tables and the curves, the extremely wide variations in proportions, finding their extreme divergence between the larval specimen and the largest adult, are well connected by intermediates. Similarly structural and color features show an intergradation between the two extremes. The number of fin rays is approximately alike in all the material examined In Specimens 3, 4, 5, 6, 7, 8, 9 and 10, the dorsal rays are 5, 171; 5, 161; 5, 170; 6, 166; 5, 170; 5, 178; 5, 170; —, 168, respectively

The larva shows a strong downward flexure of the body, and the anterior dorsal is carried on a narrow fleshy lobe extending forward and upward, from the nape, well above the transversely rounded occipital region. No such structure is shown by Emery for *Trachypterus taenia* of the Mediterranean, but a somewhat similar although probably not homologous developmental modification occurs in the postlarvae of many flat fishes (Heterosomata). The postlarva still shows a considerable body flexure, and retains the interneural-containing lobe at the base of the first dorsal. The larva is particularly extreme in proportions, the tail region being but slightly developed compared with the head and trunk (Table I), the head is relatively larger in reference to the trunk (Table II), and the eyes, jaws, etc., relatively larger in reference to the head (Table III), than in later stages The postlarva in these respects affords a complete transition between the larval and juvenile stages (Tables I–III) These changes in proportions are discussed later in the paper

The body in the young is naked, but in the adult becomes covered with pad-like scales. In the adult, also, the lateral line posteriorly becomes armed with antrorse spines. The spinules (later granulations) on the fin rays, on the contrary, disappear with age

The excessively long and flexible pelvic fin and anterior dorsal of the young — probably much longer than the body and serving as flotation organs in the larvae and postlarvae — become both proportionately and absolutely shorter with increased size, finally with age becoming obsolescent The main dorsal becomes gradually lower throughout its length. The lower lobe of the caudal, fairly well developed and with one strengthened and doubtless greatly produced ray in the larvae and postlarvae, becomes relatively small in the young and obsolescent in the adult The upper caudal lobe, scarcely evident in the larvae, becomes moderately developed in the postlarvae, then greatly elongate, like the pelvic and anterior dorsal fins, in the young, and finally very short in the adult This lobe at first extends horizontally backward, but gradually rotates to assume an antrorse direction. Essentially similar changes in the fins take place in *Trachypterus taenia*, as outlined by Emery.

Metamorphosis as determined from the changes in structure and in the fins takes place later in development than the metamorphosis in proportions. The length of the fins, when little or not at all broken, is indicated in proportionate terms in Table I.

## TABLE I

### Measurements of Trachypterus rex-salmonorum from California

This table illustrates the changes which the species undergoes with age. Measurements expressed in thousandths of total length to caudal base

| Specimen No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Length to caudal, mm | 10 | 25 | 102 | 130 | 145 | 173 | 285 | 860 | 1000 | 1520 |
| Length to anus | 850 | 665 | — | 560 | 540 | 530 | — | 383 | 403 | — |
| Greatest depth | 500 | 320 | 191 | 175 | 150 | 155 | 133 | 105 | 110 | 100 |
| Length to vertical of greatest depth | 60 | 65 | — | 60 | 70 | 100 | — | 95 | 305 | about 500 |
| Length of head | 300 | 210 | 176 | 135 | 135 | 155 | 116 | 87 | 97 | 98 |
| Length of orbit | 120 | 100 | 59 | 60 | 50 | 45 | 39 | 27 | 33 | 28 |
| Interorbital | 55 | 55 | — | 30 | 30 | 25 | — | 15 | 20 | 14 |
| Length of upper jaw | 160 | 105 | 69 | 60 | — | 50 | 49 | 32 | 35 | — |
| Length of lower jaw | 180 | 135 | — | 75 | — | 65 | — | 45 | 50 | — |
| Height of anterior dorsal | 350+ | — | 265? | — | about 320 | — | 112 | — | — | 0 |
| Height of dorsal | 250 | — | 157 | — | 120 | 135 | 84 | 60 | 70 | 49 |
| Length of caudal | — | — | 442 | 650 | 370 | 310 | 389 | 105 | 85+ | — |
| Length of pelvic | — | — | 442 | — | about 250 | — | 193 | — | 2 | 0 |

The form of the body also changes greatly with age, the depth being much the greatest between the origin of the dorsal and the sharp lower angle of the mandible in the very young, but greatest near the middle of the total length in the large adults As Sette has shown, the change in the proportionate depth of the head and trunk is not regular throughout the length of this region, the depth posteriorly increasing in reference to the depth anteriorly

The coloration also exhibits changes with age, becoming gradually more uniform. The posterior and finally the anterior spots of both dorsal and ventral series slowly disappear.

*Trachypterus rex-salmonorum*, presumably like other species of

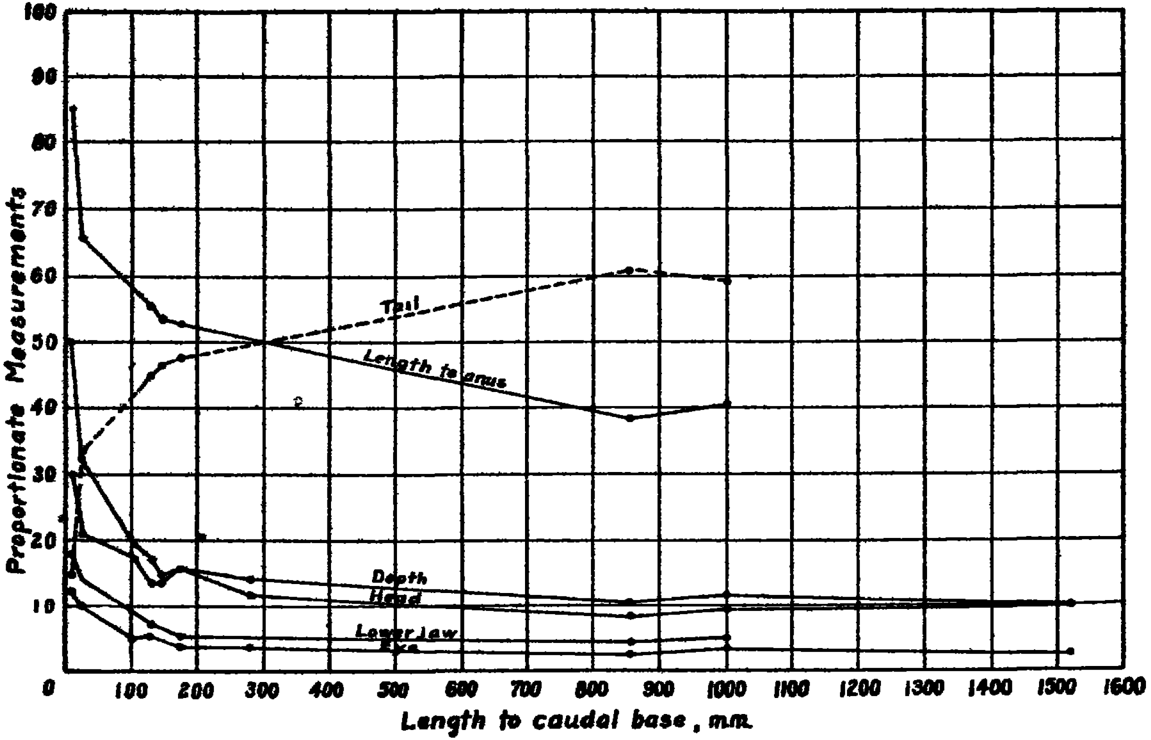

FIG 26. Graph illustrating the Metamorphosis and Age Changes in *Trachypterus rex-salmonorum*

the genus,[1] provides an exception to the general rule that, in fishes, the proportions of the head and body do not change after the postlarval period, or change proportionately to the increase in size, so that, mathematically expressed, the dimensions of any part of the body form a linear function of the total length. From Table I and Figure 26 it will be seen that the dimensions of the parts measured are not linear functions of the total length. In this species the development as regards form and proportions is of a greatly retarded type, and entails a protracted metamorphosis, the postlarval features being gradually lost during juvenile life. This situation is graphically shown in the Figure.

The remarkable changes in the proportions of the body which Trachypterus undergoes with age are due, of course, to the differential growth rate of the several parts of the body. From the graphs it is very clear that this differential growth rate is most extreme in the young, decreasing with age. The differential growth consists chiefly in the more rapid growth of the tail than of the trunk, as Sette[2] has already suggested in his study of two young specimens of this species. In the larva the anus is near the end of the body, in the young, still in the posterior half, but in the adult, in the anterior half of the total length.

There is also a differential growth in the anterior regions, the trunk growing more rapidly than the head, and the posterior portion of the head faster than the eyes, jaws, etc., these structures being relatively large in the larval and to a lesser degree so in the postlarval stages. The differential growth rate in the head-trunk region, however, characterizes chiefly the larval and postlarval stages, changes in proportions within these regions being scarcely evident in the young to adult fishes. The data are given in Tables II and III.

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[1] Carlo Emery, in 1879, discussed "Le metamorfosi del *Trachypterus taenia*" in the first paper of his series of "Contribuzioni all' Ittiologia," published in *Mitth Zoöl Sta Neapel*, 1, 1879, pp. 581–588, Pl. 18, and in *Atti Accad Lincei*

[2] *Copeia*, No 122, 1923, pp 93–96

## TABLE II

### MEASUREMENTS IN HUNDREDTHS OF LENGTH TO ANUS

| Specimen No<br>Length to caudal, mm | 1<br>10 | 2<br>25 | 4<br>130 | 5<br>145 | 6<br>173 | 8<br>860 | 9<br>1000 |
|---|---|---|---|---|---|---|---|
| Greatest depth | 59 | 48 | 31 | 28 | 29 | 27 | 27 |
| Length of head | 35 | 32 | 24 | 25 | 29 | 23 | 24 |
| Length of orbit | 14 | 15 | 11 | 9 | 8 | 7 | 8 |
| Interorbital | 6 | 8 | 5 | 5½ | 5 | 4 | 5 |
| Length of upper jaw | 19 | 16 | 11 | — | 9 | 8 | 9 |
| Length of lower jaw | 21 | 20 | 13 | — | 12 | 12 | 12 |

## TABLE III

### MEASUREMENTS IN HUNDREDTHS OF LENGTH OF HEAD

| Specimen No<br>Length to caudal, mm | 1<br>10 | 2<br>25 | 3<br>102 | 4<br>130 | 5<br>145 | 6<br>173 | 7<br>285 | 8<br>860 | 9<br>1000 | 10<br>1520 |
|---|---|---|---|---|---|---|---|---|---|---|
| Length of orbit | 40 | 48 | 34 | 44 | 37 | 29 | 34 | 31 | 34 | 29 |
| Interorbital | 18 | 26 | — | 22 | 22 | 16 | — | 17 | 21 | 14 |
| Length of upper jaw | 53 | 50 | 39 | 44 | — | 32 | 42 | 37 | 36 | — |
| Length of lower jaw | 60 | 64 | — | 56 | — | 42 | — | 52 | 52 | — |

### SUMMARY

*Trachypterus seleniris* is merely the adult of the California ribbon fish, *Trachypterus rex-salmonorum*, representing the end-stage in a development replete with structural and proportional changes.

The larvae and postlarvae show a flexure of the body, and possess a peculiar isolated nuchal lobe containing the interneurals supporting the five elongated dorsal rays The larvae exhibit one extreme of the age variations in proportions, the tail region being but slightly developed, the head, and especially the eyes and mouth, relatively very large The postlarvae afford a transition to the juvenile stages

The young are naked, the adult becoming covered with pad-like scales The lateral line becomes armed posteriorly with antrorse spines, but the granulations on the fin rays disappear with age The fin rays all become shorter with age: the excessively long pelvic fin and anterior dorsal, — probably flotation organs in the young, gradually become shorter with age — eventually obsolescent, the lower lobe of the caudal does not persist in the adult, while the upper lobe, inordinately elongate in the young, becomes very short with age and gradually rotates to assume an antrorse direction The metamorphosis as determined by changes in structure and in the fins takes place later in development than the metamorphosis in proportions

The form of the body changes greatly with age, the depth at the nape greatly decreasing with age, the depth posteriorly increasing in reference to the depth anteriorly The coloration also changes, becoming more uniform with age

The dimensions of the various parts of the body in Trachypterus are not, as usual among fishes, linear functions of the total length The development is of a greatly retarded type, and entails a protracted metamorphosis, the postlarval features being gradually lost during juvenile life.

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